Student Guide
Background Information

Directed Assistance Module 10
Turbidimeter Data Integrity

Contents

Background Information

The Surface Water Treatment Plant

In the treatment of raw surface water to produce safe drinking water, we deal with large volumes of water with often unknown and unquantified chemical and biological constituents. Because of the potential to transmit pathogens in surface water to the customers, water treatment systems use the multi-barrier approach to remove or inactivate the potentially harmful elements from the drinking water. Very generally, as shown in Figure 1, these barriers include source water protection, coagulation-flocculation, sedimentation, filtration, disinfection, and distribution. Each one of these barriers is subject to design and performance standards and regulations. These standards are

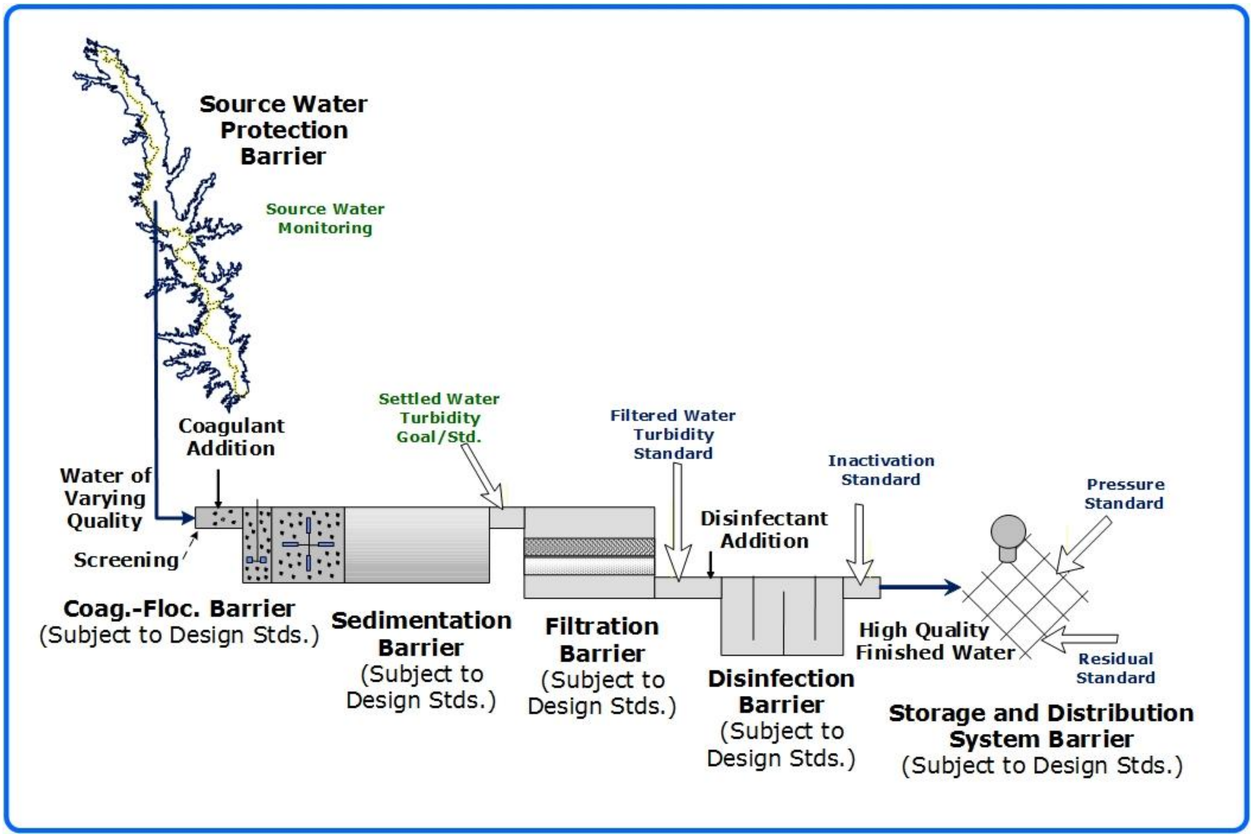


Figure 1: Multi-barrier Approach to Producing Safe Drinking Water

essential to producing safe drinking water, but even with the best designed plant and the most thoroughly planned and expertly implemented treatment process, the consumers' trust in the water system is most often based on peripheral factors that are not truly indicative of whether or not the water is safe. Their trust is freely given when the water supply meets their expectations. However, when there has been a rate increase, the water is discolored, pressures are low, drought restrictions are in place, the water tastes "different," or the CCR records at least one monitored constituent which is at a level more than three-quarters of the maximum allowable level, then the consumers quickly withdraw their trust in everyone who as anything to do with the water. We all take the blame; operators, administrators, and regulators; even when it is undeserved.

The Surface Water Monthly Operating Report

The Surface Water Monthly Operating Report (SWMOR) plays a key role in demonstrating that the water we drink meets the requirements of the Safe Drinking Water Act and is safe to drink. It also demonstrates the responsible performance of both the water system and the Texas Commission on Environmental Quality (TCEQ).

The TCEQ has been granted primacy for enforcement of the provisions of the Safe Drinking Water Act by the USEPA. The principle mechanism by which water systems report their compliance with the treated water quality standards to the TCEQ is the SWMOR. When a Surface Water Operator signs the SWMOR, he or she is certifying that the plant performance data in the report accurately reflects:

- the treatment processes at the plant, and
- the quality of the water produced.

The TCEQ receives over 300 SWMORs each month and each report has over 500 pieces of plant performance data that actually make it into the report. (The plant where the report was prepared will have collected many times that much information.)

The TCEQ reviews elements of every SWMOR. Key performance information from every report is entered into a database, and a computer program is used to identify violations, unusual patterns, and inconsistencies that deserve a more thorough evaluation of the whole SWMOR, an inquiry by Public Drinking Water (PDW) Division staff, or an on-site follow-up by a Public Water Supply (PWS) investigator. Over time, some of the more common inconsistencies in the SWMOR data have become very easy to identify. The TCEQ has found that the most common cause of these inconsistencies is that many operators have not been properly trained on how to collect, assemble, and report plant performance data. One area where additional training is needed is in the collection and management of turbidity data.

The Importance of Turbidity Data

Turbidity data is a part of the compliance record for the water treatment plant. Because the SWMOR is a legal document, when it is signed by a licensed operator, the operator is certifying the accuracy of the data in the report. That is why falsification of data in the SWMOR is a criminal offense and operators who have knowingly falsified their reports have been prosecuted, convicted, and fined. The integrity of the turbidity measurements reported on the SWMOR must be ensured by the following:

- Turbidimeter calibration records must be retained for three years. (30 TAC §290.46(f)(3)(B)(iv)) This would include the records demonstrating that the SCADA reports are within +/- 0.05 NTU of each other. (RG-211, Section 7)
- IFE turbidity monitoring results and exception reports for individual filters must be retained for five years. This includes the documentation showing when the filters were on-line or off-line and documentation showing when the filter was filtering-to-waste. (30 TAC §290.46(f)(3)(C)(iv))
- SWMORs and supporting CFE turbidity monitoring results must be retained for ten years. This includes the documentation showing when the filters were idle and when they were sending filtered water to the clearwell. (30 TAC §290.46(f)(3)(E)(i))

The term "turbidity monitoring results" means the electronic files that the HMI software generates or hard copies of the reports from the report generator. Many systems keep both. In any case, this documentation must be accessible for review during inspections.

The Turbidimeter

Principally, we will be describing single-beam nephelometry and those devices that use this technology for measuring the clarity of drinking water. We will also cover a few turbidimeter design strategies, a few innovative technologies that are sometimes useful, sources of turbidimeter error, and how instrument design and/or operations can minimize those problems.

The science:

When light passes through a water sample that contains particles, the particles obstruct the path of the light beam by either absorbing the energy or reflecting it off in a different direction. The term *turbidity* is used to describe the particles that cause the light scattering. The greater the number of suspended particles that are present in the light path, the greater the amount of light scattering that occurs.

Particle sizes of interest - Figure 2 presents a chart showing the wide range of particle sizes for contaminants found in surface water. The wide range demonstrates the need for instrumentation which can measure turbidity caused by particles whose sizes differ by many orders of magnitude.

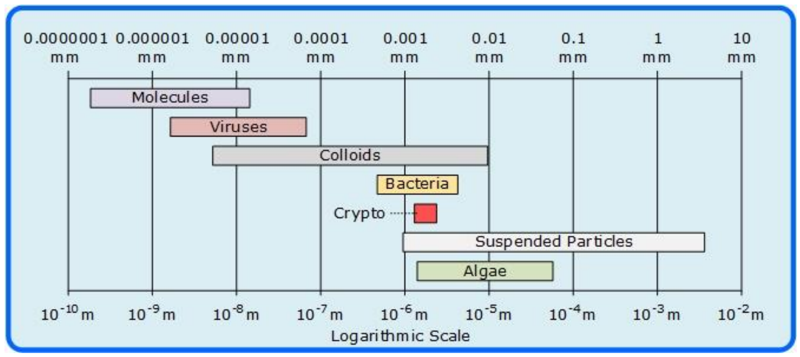


Figure 2: Size Ranges for Particles Found in Untreated Surface Water

Single beam configuration - The on-line turbidimeter, the most common device used to detect particle breakthrough in gravity filters, operates using this light-scattering principle. Turbidimeters measure the light scattered 90-degrees from the path of a beam of light passed through a water sample (see Figure 3). Note that sometimes there is an additional detector measuring the light that passes straight through the sample. Scatter is caused by particles, even though some of the light hitting the particles is absorbed. Therefore, the turbidity measurement is an expression of the optical properties of the sample which cause light rays to be scattered and absorbed rather than transmitted in straight lines through the sample.

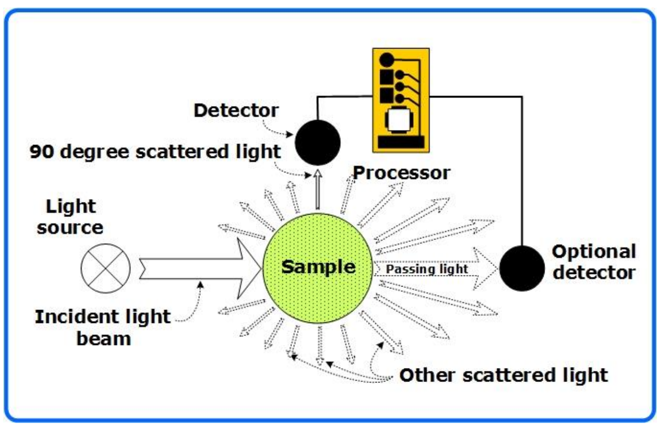


Figure 3: The Turbidimeter Measures the Light Scattered at 90-Degree from the Incident Light Beam

Why 90 degrees? - Different sized particles scatter light differently. As shown if Figure 4, small particles (<0.1 the wavelength of light) scatter symmetrically both forward and backward. Large particles (0.25 the wavelength of light) scatter more forward than backward. Even larger particles (>0.25 the wavelength of light) scatter much more forward than backward, and in general more irregularly. However, light scattering is most consistent at a 90 degree angle from the incident light, regardless of particle size. This allows for the highest accuracy of measurement in spite of differing particle size.

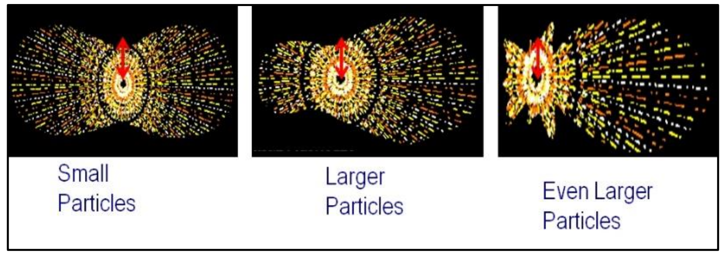


Figure 4: Scattering of Light by Particles of Different Size

Design requirements - Turbidimeters must be designed so that they are sensitive enough to detect a few particles but remain accurate (linear) when large numbers of particles are present. Instrument sensitivity and linearity are achieved by controlling the intensity of the light passing through the sample and the distance between the light source and the sensor that is used to measure the scattered light. In theory, increasing the sensitivity of a turbidimeter (by increasing the intensity or the distance) inevitably leads to a loss of linearity at high concentrations. For example, most modern on-line turbidimeters that use incandescent bulbs or LEDs have been designed to produce accurate readings even when turbidity levels approach 100 NTU. On the other hand, many of these units are unable to accurately measure levels that are much lower than 0.10 NTU. Recent developments in technology have improved sensitivity through the use of a high-intensity laser as the light source and a highly sensitive detector; these new units can accurately measure turbidity levels that are below 0.02 NTU or are as high as approximately 5.0 NTU.

Regardless of what kind of light emitters and sensors are used or where they are located, mathematical algorithms (or formulas) are used to calculate the turbidity value of the sample based on the light scatter generated using one or more turbidity standards. Consequently, on-line turbidimeters must be calibrated with a primary standard periodically and their performance must be verified using secondary standards, proprietary verification devices, or by comparing the results with benchtop units.

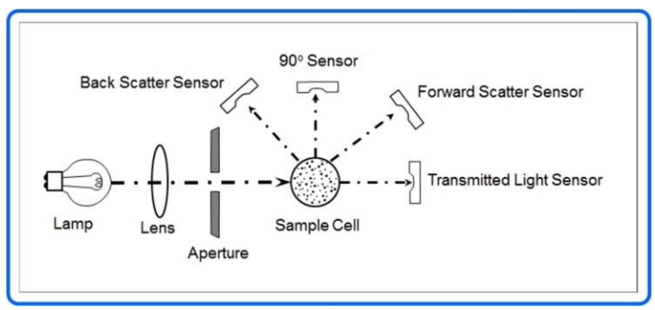


Figure 5: Representation of a Ratio Turbidimeter

Ratio turbidimeters – Most turbidimeters use the single beam strategy shown in Figure 3. Some turbidimeters incorporate forward-scatter and back-scatter sensors and a sensor to detect the amount of light that passes through the sample without being scattered; turbidimeters that have more than the 90^{o} detector, as shown in Figure 5, are commonly called *ratio turbidimeters*. Notice that they still use a single beam of light.

Figure 6: Hach 1720E

Specific applications of nephelometric technology

Hach 1720E – The Hach 1720E is the most commonly used turbidimeter in Texas. This turbidimeter uses the single beam technology, a tungsten lamp as the light source, the sensor (photocell) is immersed in the sample, and the turbidimeter logs time stamped turbidity measurements internally. Several different controllers can work with the 1720E and the operator's choice of controller will depend on the functions needed and the SCADA system and/or recording device that will serve to log the turbidity data.

In the past, earlier models of the 1720 series were commonly used in Texas. However, Hach no longer provides parts or support for these older instruments, and they are not covered in this DAM.

Hach Surface Scatter 7 and AMI Turbiwell – The Scatter 7 and Turbiwell (see Figure 6) are two designs that share a couple of features. Both of the meters are single-beam nephelometers, and neither uses a sample cell or has a submerged photodetector/sensor. Although they both use the EPA 180.1 method and have 400 – 600 nm peak spectral response, the Hach Surface Scatter unit uses a tungsten-filament bulb while the Swan Turbiwell uses a white LED light source.

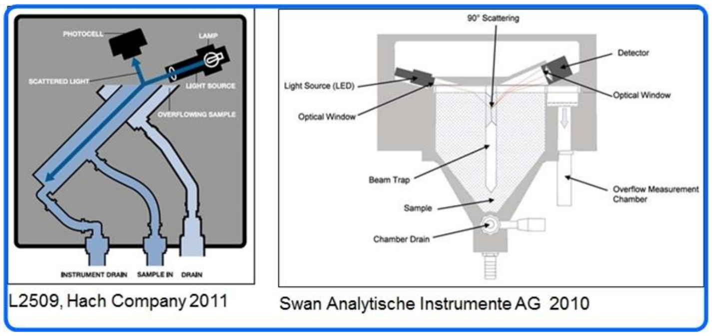


Figure 7: Dry-Sensor On-line Turbidimeters

HF Scientific MicroTol - The Microtol turbidimeter (see Figure 7), like the Hach 1720e (and most other on-line turbidimeters), uses a single beam design. However, unlike the 1720 units, the sensor in the Microtol unit is located outside of a 30 mL glass sample cuvette instead being submerged directly in the water. Like most other manufacturers, HF Scientific produces one model of the Microtol that meets EPA Method 180.1 requirements and another model that meets ISO 7027 requirements. The model that meets EPA Method 180.1 requirements utilizes a krypton-filled tungsten light bulb to produce a white light.

Figure 8: HF Scientific MicroTol Turbidimeter (Another Dry Sensor Technology)

Great Lakes Instruments - Another type of turbidimeter technology, the Great Lakes Instruments Method 2 (see Figure 8), uses alternating LED light sources with photo detectors to measure the turbidity.

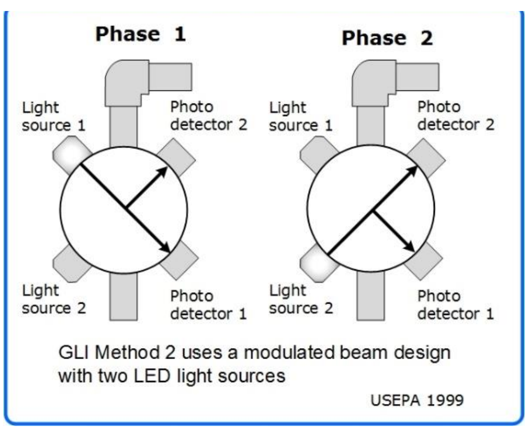


Figure 9: GLI Method 2 Turbidimeter

Hach FilterTrak 660 - The FilterTrak 660 uses a laser source instead of an incandescent bulb. In many respects, the FilterTrak 660sc and 1720e turbidimeters are similar. For example, the turbidimeter bodies look very much alike, both instruments use a submerged photodetector (sensor), and both use a single beam design. However, there are significant differences between the light sources and electronics used by the two instruments. While the 1720 turbidimeters use the tungsten lamp as their light sources, the FilterTrak turbidimeters use a monochromatic 660 nm laser.

Sources of Turbidimeter Measurement Error:

Operators have been known to reject the readings of on-line meters and substitute turbidity readings from grab samples analyzed with a benchtop turbidimeter. This is primarily because they believe that the benchtop device is more accurate. If both the benchtop and the on-line instrument are maintained properly, this assumption is entirely false. Both benchtop and on-line turbidimeters are subject to factors that lead to measurement error, but the elements of design that compensate for these errors work in favor of the on-line instruments. Turbidimeter performance can be affected by several factors which include:

- lack of proper calibrations and performance checks;
- poor maintenance;
- the number of particles present;
- the size and shape of the particles;
- unreliable power supply;
- true color;
- the presence of air bubbles;
- the presence of particles that adsorb light (carbon particles, for example); and
- the presence of stray light.

Lack of calibration and maintenance – A poorly maintained and seldom calibrated instrument cannot be expected to produce accurate results, but the fault does not reside with the manufacturer or the instrument.

- Primary calibrations:
    - Standards for primary calibration of benchtop instruments are normally purchased from the turbidimeter manufacturer, and properly taken care of, can be used for the entire useful life for which they are certified to be valid.
    - When primary calibrations of benchtop instruments are performed, the secondary standards, which must be used on a daily basis must be restandardized so that they can be relied on between primary calibrations.
    - Standards for primary calibration of on-line turbidimeters may be purchased or user prepared. Both have a shelf life and both require precise adherence to the manufacturer's instructions. This prolongs the life of the vendor prepared standard, and ensures that the user prepared standards can provide accurate calibrations.
    - User prepared standards for calibration of on-line instruments must be prepared using laboratory grade volumetric flasks and pipetting equipment. Calibrations performed without precise volumetric measurements will produce calibration errors.
- Secondary calibrations (performance verifications):
    - Regular primary calibrations are a guarantee of good instrument performance but the secondary calibrations, or performance verifications, are essential to ensure continuing good performance between the primary calibrations.

- In order to use secondary standards provided by a manufacturer, the turbidity measure of the secondary standard must be checked after every primary calibration and a new turbidity value for that standard should be assigned to it. The restandardization of the secondary standards must be performed or the primary calibration is incomplete. This is true of standards for both benchtop and on-line instruments.
- With on-line instruments, however, the operator may choose to perform a comparison test. Instead of using a secondary standard provided by the manufacturer, the operator may choose to compare the turbidity measurement of the on-line instrument to the turbidity measurement of the same sample with a benchtop instrument that has received a primary calibration within the last 90 days, and was confirmed to be measuring accurately using a secondary standard at the time of the performance verification.

- Maintenance for benchtop instruments:
  - Keep the turbidimeter and accessories clean.
  - Use a cloth dampened with mild detergent and water when the enclosure and keypad require cleaning.
  - Wipe up spills promptly.
  - Wash sample cells with nonabrasive laboratory detergent, rinse with distilled or demineralized water, and air dry.
  - Avoid scratching the glass cells, and wipe all moisture and fingerprints off of the cells before inserting them into the instrument.
  - When measuring very cold samples, it may be necessary, if one is provided, to use an air purge facility to prevent condensation from collecting on the outside of the sample cell.
  - The manufacturer of your turbidimeter may have other maintenance suggestions or requirements. Be sure to check your manual.
- Maintenance for on-line turbidimeters:
  - In addition to routine replacement of bulbs and sensors (photocells) when necessary, it also necessary to clean the photocells, sample chamber, and bubble trap.
  - Water that has the smallest amount of nutrient value can result in bacterial growth. Oils and other contaminants are sometimes found in water and can build up on sensors. Because the the light in the tungsten bulb is always burning inside the sample chamber, even algae can grow inside the turbidimeter. These accumulations, of course, will interfere with the ability of the sensor to detect reflected light.
  - Scaling, which can accumulate in poorly maintained turbidimeters, interferes with turbidity measurements by obstructing the light as it enters the turbidimeter or by preventing the light from reaching the sensor. Most manufacturers design their turbidimeters so that they can be disassembled and cleaned with a lint-free, non-abrasive cloth.
  - Since scale can also accumulate in, and be dislodged from, the sample line, manufacturers often specify the type and length of sample tubing that should be used with their meters.
  - Cleaning should be performed before every primary calibration and is optional before performance verifications.
  - Cleaning should be performed after every confirmation failure.
  - Cleaning the sensor should be performed, prior to other maintenance alternatives, whenever there is an indication that there is a low signal.

- Cleaning the bubble trap, sample chamber and sensor should be performed when one observes "noise" in the displayed turbidity. Rapid fluctuations in turbidity can be due to air bubbles making it through a dirty bubble trap.

Number of particles – When the number of particles becomes a problem in measuring turbidity, the water being analyzed is not within the regulatory range for IFE turbidity and/or CFE turbidity. This factor does not come into play when collecting compliance data unless a violation exists.

Size and shape of particles - Since small and large particles tend to scatter different wavelengths of light, we use nephelometric science (the measure of light that is scattered at 90 degrees from the incident beam) to measure the clarity of the water (see Figure 3).

Unreliable power supply – At some plants where the power supply is inconsistent, a means of regulating the electrical supply may be required. If this is true, there is no substitute for an alternating current power conditioning unit. Because of the range in size of the particles we measure with turbidimeters, we need a wide spectrum of light frequencies to measure the turbidity. Incandescent bulbs serve this purpose, but when incandescent light bulbs are used, the wavelengths being emitted will depend on how much current is passing through the filament. Therefore, having a well-regulated power supply is important when using incandescent bulbs. Figure 9 shows the effect of a power conditioning unit on a power supply with fluctuating voltage. An erratic power supply serving a computer storing electronic data files, and performing other electronic control functions (such as operating automatic alarms and shutdowns), may require AC power conditioner.

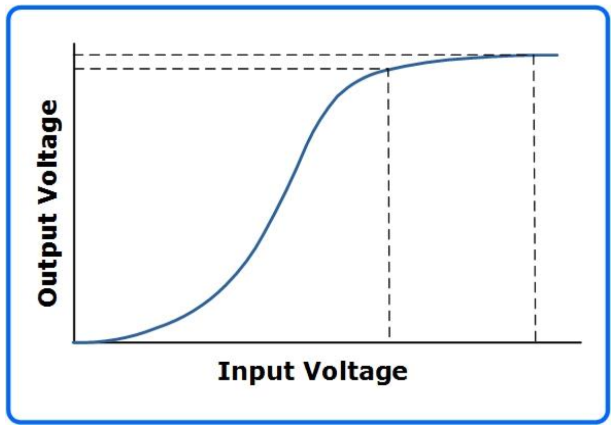


Figure 10: The Effect of Power Conditioning for an Unreliable Power Supply

For turbidimeters using light emitting diodes (LEDs), which tend to produce the same wavelength of light regardless of the amount of current passing through the diode, regulated power is still needed to make sure the diode does not burn out.

True color - Color affects benchtop and on-line instruments alike. True color is produced when dissolved chemical compounds (particularly naturally-occurring molecules such as humic and fulvic acids) absorb certain wavelengths of light. Since true color can absorb light, it can result in erroneously low turbidity readings unless the turbidimeter manufacturer has taken precautions to reduce this interference. Some manufacturer's use monochromatic light sources (such as LEDs) to reduce this interference while others use sensors which are less sensitive to these wavelengths of light. Still others utilize ratio turbidimeters with multiple sensors. When a plant has colored water for


Figure 11: True Color Interference

which the turbidimeter design does not provide an accurate measurement, an exception may be requested from the TCEQ to apply a specific dose of a mild acid to the sample cell to oxidize color causing compounds, thereby, allowing the operator to measure the turbidity accurately.

Figure 13: Air Bubble Interference

Air bubbles - Like particles, air bubbles will scatter light. Consequently, turbidity values will be erroneously high if air bubbles are present. The solubility of air in water is affected by both temperature and pressure. Consequently, some manufacturers design their turbidimeters as closed systems which maintain the water pressure at the same pressure as the water leaving the filter. Other manufacturers incorporate integral bubble traps which allow the bubbles to be captured in a baffle chamber before the water reaches the chamber where turbidity is measured. However, with the benchtop units, one has to wait until the bubbles emerge from the sample or apply a small vacuum to the sample cell to pull the air out of the sample. Some on-line instruments also have another feature that is used to minimize the impact of bubbles that are not caught by the bubble trap. These on-line instruments use an exclusion algorithm and signal averaging to minimize the impact of the bubbles. In the chart in Figure 12, significant noise is observed in the raw turbidity readings because of bubbles. The true turbidity is the bottom values of the blue line, as all bubble noise is a positive interference. The green line shows the median turbidity values after the exclusion algorithm is applied and the red line is the turbidity value after signal averaging is applied. The benchtop devices do not apply these corrections to the turbidity measurement. Since air bubbles may form as the water temperature increases, sample lines for on-line turbidimeters should be as short as possible to prevent significant temperature changes before the water reaches the turbidimeter. Sample spigots installed in the plant laboratory for taking grab samples from transfer lines sampling water at remote locations may also be subject to temperature change and subject to emerging air bubbles.

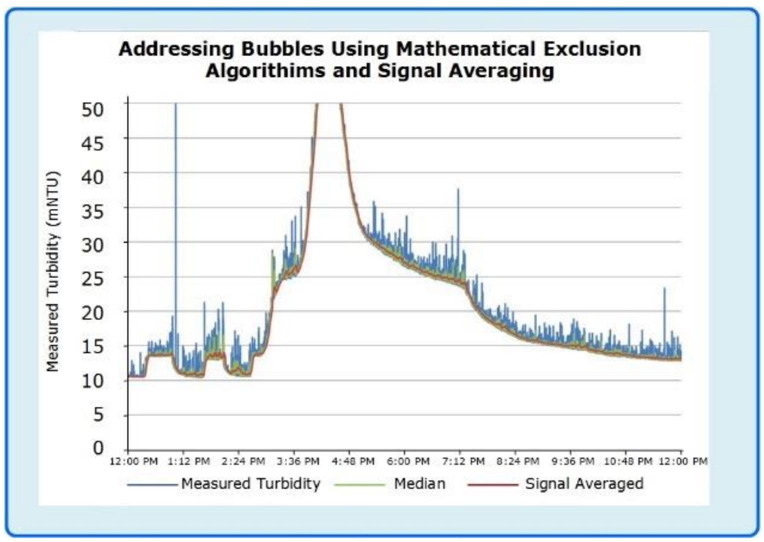


Figure 12: Reducing Measurement Error Due to Bubbles

Light absorbing particles – Particles that absorb light reflect less light and can result in lower turbidity measurements. Ratio turbidimeters are designed to account for these types of particles and can produce reliable results. However, most of the light absorbing particles will be removed by filters and have no impact on compliance measurements for IFE and CFE turbidity. The measurement of raw or settled water turbidity has more degrees of tolerance for sample error (less precision is required) but using a ration turbidimeter for these samples is advised.

Stray light – Stray light becomes the main source of turbidimeter measurement error when the instruments are well maintained and the color and bubbles are dealt with. Therefore, controlling the amount of *stray light* is an important aspect of turbidimeter design.

Figure 14: Stray Light Interference

The term *stray light* is used to describe any energy (light) reaching the sensor that was not produced as a result of particle scattering. Since the sensor cannot distinguish between the light generated by particle scatter from that produced by other sources, the turbidimeter light source, sensors, and housing must be designed to minimize the interference from stray light. Designs that do not control stray light well have a low sensitivity (*i.e.*, low accuracy when particle concentrations are low).

Scratched sample chambers can change the direction of the light beam and, consequently, can result in increased levels of scattered light and erroneously high turbidity readings. Some manufacturers avoid this problem by immersing their sensor directly in the sample stream.

Table 1 shows the impact of stray light on three different types of calibrated Hach turbidimeters. The instruments were used to measure the turbidity of water produced by a reverse osmosis (RO) process and the turbidity measurements for the water should have been at the lower limit of the instrument range for all three instruments. The test results were as follows:

- The 2100N benchtop turbidimeter measured the turbidity as 0.025 to 0.035 NTU.
- The 1720E on-line turbidimeter measured the turbidity of the same water as 0.015 to 0.020 NTU.
- The FT660SC measured the turbidity of the same water as 0.007 to 0.010 NTU.

Table 1: The Impact of Stray Light on Hach Turbidimeters

Stray Light Source	2100AN	1720E	FT660SC
Glass Surfaces (Sample Cells)	Present – moderate reduction with silicone oil	None – detector in sample	None – detector in sample
Light Source	Poly-chromatic and divergent. Uses many apertures	Poly-chromatic and divergent. Uses 1 aperture	Mono-chromatic and non-divergent. No aperture is needed
Internal Surfaces	Black but susceptible to dust	Black and light trap on bottom to minimize reflection	Black and light trap on bottom to minimize reflection
Estimated Reading of RO Water – Higher reading = higher stray light (in NTU)	0.025 - 0.035	0.015 – 0.020	0.007 – 0.010

Because we know that the RO water would have a turbidity at the "zero" on the instrument scales, the measured turbidity was due to positive interference of stray light. The error for the benchtop instrument was 66 to 200 percent greater than the error for the online instruments for the same water. Excepting for waters with true color, the on-line instruments provide more accurate measurements than the benchtop devices.

On-line versus benchtop measurements for IFE turbidity

Unless a system has an exception under 30 Texas Administrative Code (TAC) Chapter §§290.42(d)(11)(E)(ii), IFE turbidity measurements must be made every 15 minutes by an on-line turbidimeter and the readings must be recorded by a SCADA system or strip chart recorder. If an operator suspects that the on-line instrument is not performing properly it must be repaired or replaced with an on-line instrument that does perform correctly within the number of days specified in 30 TAC §§290.111(e)(5)(C)(ii & iii). The bottom line is, the IFE turbidity measurements taken by the on-line instruments determine the compliance status of the filters: substituting preferred benchtop turbidimeter readings for IFE turbidity is a monitoring and reporting violation.

The SCADA System

The Supervisory Control and Data Acquisition (SCADA) system consists of many components which are designed to work together to ensure plant performance data are gathered and recorded as accurately as possible. The system may also be capable of running certain parts of the treatment process, or it may be capable of allowing the operator to run the plant from the control room. However, we will discuss the way the SCADA system records turbidimeter data.

Components of the SCADA System Gathering Turbidity Data

The components of the SCADA system (Figure 14) that collect turbidity data are the turbidimeter, the transmitter, a programable logic controller (PLC), a computer with human machine interface (HMI) graphical software, and a report generator from which data may be assembled for the SWMOR.

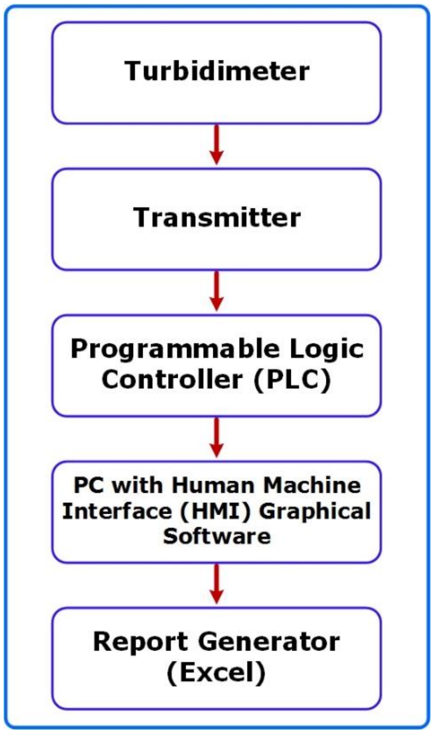


Figure 15: Turbidity Gathering Elements of SCADA Systems

Turbidimeter and transmitter - The turbidimeter and transmitter do not become a part of the SCADA until they are configured to communicate with the PLC and the PLC is configured to receive the data the transmitter sends.

- Transmitters typically send a four to twenty (4 – 20) milliamp (mAmp) analog signal representing the turbidity measured by the turbidimeter. This means that if the turbidity is zero, the transmitter will send a 4 milliamp signal to the PLC.
- The SCADA contractor or the operator sets the transmitter to send a 20 mAmp signal when the highest turbidity it can send occurs. This "highest" turbidity setting should represent, at least the full compliance range for the turbidity being measured (at lesat 2.1 NTU for IFE and at least 5.1 NTU for CFE).
- When the transmitter is connected to a PLC or computer that is a long distance away, the transmitter may need to be equipped with a special cable to avoid loss of some of the analog signal before it reaches the PLC. (See your operations manuals.)
- Some transmitters send a digital signal that is more reliable than the analog signal, but these are much more expensive.

Programmable Logic Controller (PLC) – The PLC is the device that receives the information from the transmitter and, in some instances, would shut down the plant if the turbidity exceeded the shutdown trigger. However, with respect to turbidity measurements, the PLC interprets the signal from the transmitter and forwards the information to the computer.

The PLC may also determine whether or not the measurements it receives are valid compliance data. For example, if the PLC recognizes that a filter is undergoing a backwash or filter-to-waste cycle, it may exclude the turbidity data it receives from that filter from the compliance record. Not all PLCs are programmed to perform this function, and if they do not, the operator has to exclude data which are not a part of the compliance record.

Personal computer (PC) with Human Machine Interface (HMI) Software – The PC with HMI software assembles the data from the PLC into a table or chart that can be viewed on the computer screen. Typically, when tables with the turbidity measurments are produced, the tables include the ID for the filter or turbidimeter that the turbidity measurements came from, and the time that measurements were performed. When charts are produced, they typically include a color coded legend and trend lines showing the turbity versus time for each of the filters. Also, the scales for the horizontal and vertical axes can normally be adjusted to suit the operator viewing the data.

Report generator – The report generator may be quite simple, but it could also be quite complex. The simplest simply receive the tables and/or charts and print them out. The more complex can migrate the information into a series of reports or directly into the SWMOR. When providing the specifications for the SCADA system, the operator or purchasing official must indicate the type of report they want the SCADA system to produce. When they do not, the SCADA contractor may not provide a report generator.

Common Issues with SCADA Systems

The TOP has evaluated many turbidity data reports for a lot of surface water plants and found many common issues, from the turbidimeter to the report. These include:

Lack of performance - The operator does not perform performance verifications on the SCADA system when the on-line turbidimeters are calibrated.

- For SCADA to be used for compliance reporting, reported data must be calibrated with the instrument. The turbidity measurement readings at the HMI should be the same as the readings on the instrument display after each primary calibration.
- Turbidimeter calibration records and SCADA performance confirmations and/or adjustments should parallel each other.
- Each step in the data custody chain must be evaluated from time-to-time to ensure each all adjustments and data records reflect consistent values:
    - the turbidimeter display,
    - the transmitter signal adjustment,
    - the HMI charts and/or tables,
    - The operator should routinely perform spot checks of the instruments reported value compared to the HMI and reported value is important.

Date-time stamps - The turbidimeter, PLC, HMI, and report generator must be adjusted to the same date and time. When they are not, any information downloaded from the turbidimeter will differ from that downloaded from the SCADA computer.

- The date-time setting should be within a minute of each other to minimize the difference between the turbidity data records.
- If the instrument log is registering at 15-minute intervals and the HMI is registering at 15-minute intervals, but the intervals are off by several minutes, the turbidity values can be significantly different.
- This most often happens when an old turbidimeter is replaced by a new one and the new instrument is not set up properly. Turbidimeters typically have a default start date and time in the data register that does not match the current date and time and can be off by several years.

Capped transmitters - The turbidimeter and controller (i.e., SC100, SC200, etc.) will measure and display the correct turbidity measurements if the instrument is calibrated and operated correctly. However, the transmitter can be capped at a level lower than that required for filter performance data.

- IFE turbidity data records must be able to demonstrate that the filter has not produced filtered water with a turbidity of 2.0 NTU, therefore, the data transmission range must be from zero to at least 2.1 NTU.

- CFE turbidity data records must be able to demonstrate that the bank of filters has not produced water with a turbidity above 5.0 NTU, therefore, the data transmission range must be from zero to at least 5.1 NTU.
- Even though the transmitter must be able to send data records with larger data transmission ranges than typically measured by the turbidimeter, the PLC and the HMI software should be able to adjust the scale on any charts it sends to the display screen. This will allow the operator to accurately interpret the display data. (Some HMI software does not come with this feature unless it is part of the specifications, when purchased.)
- Precision of the turbidity data is important and the sophistication of the hardware comes into play.
    - PLCs should be at least 12-bit processors. This means that when the transmitter is sending a 4 to 20 mAmp signal to the PLC, the precision of the CFE turbidity measurement can be represented by the following equation:

$$Resolution\ of\ the\ measurement\ signal = \frac{Turbidity\ range}{2^{12}} = \frac{Turbidity\ range}{4096}$$

    - Therefore, when the CFE turbidity range being measured is from zero to 5.1 NTU, then:

$$Resolution\ of\ the\ measurement\ signal = \frac{5.1\ NTU}{4096} = 0.00125\ NTU$$

    - Even if the PLC had only an 8-bit processor (which would be really, really old technology), the equation would be:

$$Resolution\ of\ the\ measurement\ signal = \frac{5.1\ NTU}{2^{8}} = \frac{5.1\ NTU}{256} = 0.02\ NTU$$

    - The required accuracy for turbidity compliance data is +/- 0.05 NTU. Therefore, with a turbidity range from zero to 5.1 NTU, the resolution of the reading received by the PLC is plus or minus 1.25-thousandths of an NTU if a 12-bit processor is used and is plus or minus 0.02 NTU if an 8-bit processor were used. This resolution is precise enough to capture, display, and assemble plant performance records for compliance reporting.
    - For these reasons, the transmitter sending turbidity measurements to the PLC do not have to be capped below the upper limit of the compliance range.

HMI and report generator software limitations - The HMI software may have very limited features unless the purchasing official specifies a more versatile display and output protocol. The TOP has found some turbidity versus time displays that are limited in the following ways:

- The chart displayed on the computer screen cannot be printed to provide a hard copy. Therefore, the operator has to check the data on screen or in a chart printout to determine the 15-minute IFE turbidity readings or the 4-hour CFE turbidity readings.
- The HMI software has a memory buffer that lasts only a week (or less) and does not allow the charts or tables to be saved in an independent file.
- The operator cannot adjust the vertical and/or the horizontal scales to:
    - show the entire range of turbidity values the turbidimeter is measuring, or
    - show the measured turbidity on a scale that allows the low-level compliance data to be accurately interpreted by the operator.

Recommendations for HMI and report generator software – Ideally, the HMI and report generator software should have the following features:

- The software should provide electronic turbidity data storage that can be retrieved by the operator when needed.
  - The software should allow the turbidity data files to be printed when a hard copy is needed.
  - The software should allow the turbidity data files to be exported to Excel to allow:
    - comparison of turbidity data with other plant performance data,
    - construction of filter performance trend charts,
    - use of macros and spreadsheet formulae to select the maximum daily IFE turbidity for each filter, the IFE turbidity four hours after a startup (if required) and six 4-hour CFE turbidity readings each day.
  - The software should allow the operator to know when the plant is on-line or off-line, and when a filter is on-line, off-line, or filtering-to-waste. This feature facilitates selection of:
    - the highest daily IFE turbidity for each filter,
    - the 4-hours after startup turbidity (if required), and
    - the correct 4-hour CFE turbidity readings (if these are collected using an on-line instrument).
- The software should allow the operator to exclude turbidimeter calibration events from the IFE and CFE turbidity compliance records.
- The report generator should be able to produce both turbidity versus time charts and time-stamped turbidity data tables.
- When charts are provided, it is best if the operator can specify the scale on the vertical and horizontal axes.
- It is also best if the operator can select or deselect turbidity outputs (which filter turbidities, the CFE turbidity, etc.) should be displayed on a chart.
- Both the turbidity charts and tables must present data within +/- 0.05 NTU of the reading captured by the calibrated on-line turbidimeter.

Unattended operation - If the plant operates when no operators are present, the plant must have a call-out alarm that notifies an operator when the IFE or CFE turbidity reaches a certain level. Additionally, the plant must have an automatic shut-down mechanism that prevents filtered water that does not meet the treatment technique requirements of 30 TAC §290.111 from entering the clearwell.

- And must be provided to the TCEQ when requested. (30 TAC §290.46(f)(1 & 2))

Examples of Data Integrity Issues

The following examples describe data integrity issues found by TCEQ inspectors during Comprehensive Compliance Investigations (CCIs) or the TOP during Special Performance Evaluations (SPEs) and mandatory Comprehensive Performance Evaluations (mCPEs).

Example 1:

During a mCPE, the TOP performed a data review and discovered:

- The IFE and CFE turbidity values recorded on the daily bench sheets did not match the corresponding readings recorded on circular charts or in the plants' electronic records. (Both were employed by the system.) This did not comply with the requirement that turbidity data collected by multiple mechanisms must always be within 0.05 NTU of each other, in accordance with the accuracy and precision standards mandated by the EPA and the TCEQ *Regulatory Guidance Document RG-211*.

- The IFE and CFE turbidity values reported on the system's SWMORs did not correspond to plant records. The chief operator routinely reported turbidity data he knew to be inaccurate. The reported data did not include events exceeding the IFE and CFE turbidity records in the circular charts, turbidimeter electronic files, or SCADA records.
- The settled water turbidity levels reported on the SWMOR did not match the results shown on the daily bench sheets. The only settled water turbidity value recorded on the SWMOR by the chief operator was 0.2 NTU. The WTP's on-line instruments, data recording systems and daily test sheets recorded settled water turbidity values more than 100 times higher than this value.
- The operators did not calibrate the on-line turbidimeters and perform performance verifications in accordance with state and federal requirements.
  - The on-line turbidimeters must be calibrated using primary standards at least once every 90 days to ensure accurate turbidity measurements used for compliance reporting.
  - Additionally, there are weekly performance checks that are required to ensure that the instrument is still measuring turbidity accurately.
  - When the weekly performance verification shows that the on-line turbidimeter is not measuring accurately, it must be recalibrated using a primary standard.
- The operators did not properly calibrating the benchtop turbidimeter.
  - Benchtop turbidimeters must be calibrated with primary standards at least once every 90 days.
  - Each time the turbidimeter is calibrated with primary standards, the secondary standards must be restandardized.
  - The secondary standards must be used each time a series of turbidity tests are run to ensure that the benchtop turbidimeter is still calibrated.
- The circular charts used for analog data recording were not properly adjusted to ensure that they record the same turbidity values measured by the turbidimeters.
- The operators were not sufficiently familiar with regulatory reporting requirements or they were aware and did not comply with the reporting requirements.
  - SWMORs are legal documents which are certified true by the operator's signature. The SWMORs submitted by this plant operator were not true records of plant performance data.
  - When settled water turbidity is reported on the SWMOR, the value must correspond to an actual settled water turbidity measurement. As stated above, the chief operator reported the settled water turbidity as 0.2 NTU for several consecutive years.
  - For confirmed IFE turbidity excursions above 1.0 NTU, the system is required to perform certain studies and to complete additional reports that must be submitted with the monthly SWMOR. The IFE did not report confirmed IFE turbidity excursions above 1.0 NTU, even though they occurred often, and did not submit the additional reports.
  - For confirmed IFE turbidity excursions above 2.0 NTU in consecutive months, the system is required to submit a request for a mCPE performed by a third party. The SWMOR did not report confirmed IFE turbidity excursions above 2.0 NTU, even though they often occurred in consecutive months, and the system did not request a mCPE.

- A system must consult with the TCEQ within 24 hours if there are any CFE turbidity readings above 1.0 NTU and must notify their customers via radio and TV stations within 24 hours if they cannot reach the TCEQ. The system did not consult the TCEQ about CFE turbidity excursions above 1.0 NTU and did not notify their customers of the same, even though they occurred regularly.

The chief operator for this system was fired, received a criminal conviction, and was fined by the court for falsifying government documents which he had certified to be true.

Example 2:

During a CCI performed by a TCEQ regional office investigator, the investigator downloaded the turbidity record from one of the 1720E turbidimeters monitoring IFE turbidity. The investigator found:

- The IFE turbidimeter had 210 days of 15-minute IFE turbidity data logged by date, time, and value. These data were compared to the WTP's SWMORs for the same period to determine when the plant and filter were on and off-line. Because the turbidimeter file and the SWMORs did not match, the investigator requested assistance from the TOP. Using the records provided by the investigator, the TOP developed the chart in Figure 15 to compare the reported versus recorded turbidity records. Care was taken to only include maximum daily turbidities from the 1720E data log if it was actually a "confirmed" reading (i.e., there were at least two consecutive readings above the 1 NTU and 2 NTU triggers) and the plant was actually on line during the period when the data was collected.

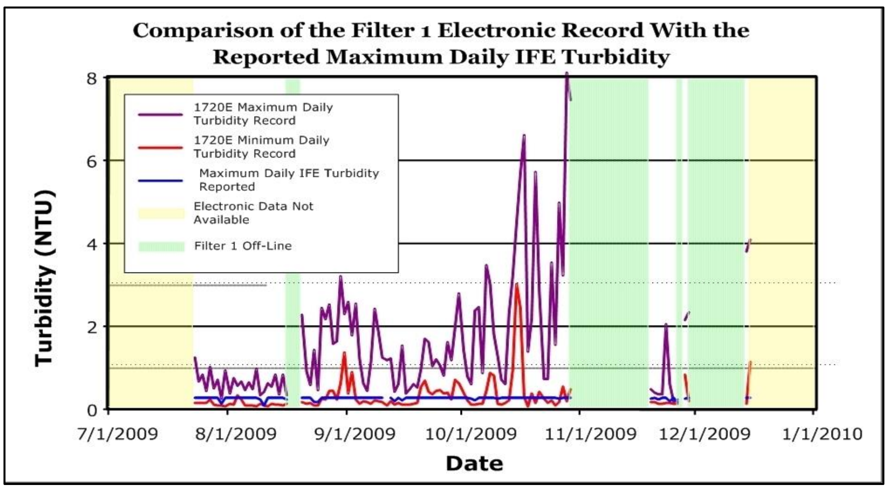


Figure 16: Comparison of IFE Turbidimeter Records and a Plant's SWMORs

- Figure 15 shows:
  - There are large swings in the IFE turbidity for Filter 1 indicating severe filter performance problems. These turbidity excursions above the regulatory filter performance trigger levels were never reported on the SWMOR.
  - The maximum daily IFE turbidity levels reported on the SWMORs were 0.29 NTU or less for the entire period.
  - On three occasions, the 1720E log contained a maximum daily turbidity less than 0.29 NTU (July 30th, November 25th, and November 26th, 2009). On November 25th, the system reported a maximum daily IFE turbidity value of 0.29 NTU while the maximum turbidity in the electronic log was only 0.18 NTU.
  - The maximum daily IFE turbidity in the 1720E data log exceeded 1.0 NTU, at least once every month from July to, and including, December 2009.
  - The maximum daily IFE turbidity in the 1720E data log exceeded 2.0 NTU, at least once every month from August to, and including, December 2009 on a total of 18 days when the SWMORs showed the plant to be operating at times the high readings were recorded.

- The minimum daily IFE turbidity in the 1720E data log was often higher than the reported IFE turbidity. The minimum 1720E turbidity was above 1.0 NTU on 4 days and above 2.0 NTU on 2 days, while the Filter 1 IFE turbidity reported in the WTP's SWMORs never exceeded 0.29 NTU.

The chief operator for this system was fired, received a criminal conviction, and was fined by the court for falsifying government documents which he had certified to be true.

Example 3:

During a project in which the TOP staff was providing SPE training for a TCEQ investigator, the trainers demonstrated how to perform a data audit and found that the system had triggered a mCPE. During the following mCPE, the TOP assembled the chart in Figure 16, which compares IFE turbidity data gathered using a TCEQ turbidimeter and the IFE turbidity record maintained in the plant SCADA system for the same filter.

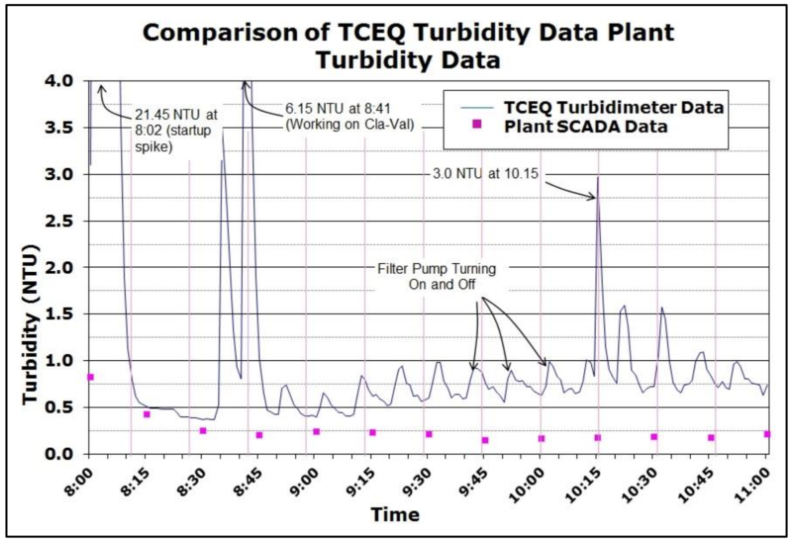


Figure 17: Comparison of TCEQ IFE Turbidimeter Data and Plant SCADA Data

- The turbidity levels recorded by the SCADA system are clearly capped at a level that would indicate IFE turbidity compliance.
- When the IFE turbidity was above 4.0 NTU, the SCADA system recorded IFE turbidity values less than 1.0 NTU.
- During the course of the filter run, the IFE turbidity hovered at just below 0.25 NTU, even though there were regular IFE turbidity excursions above 0.5 NTU.

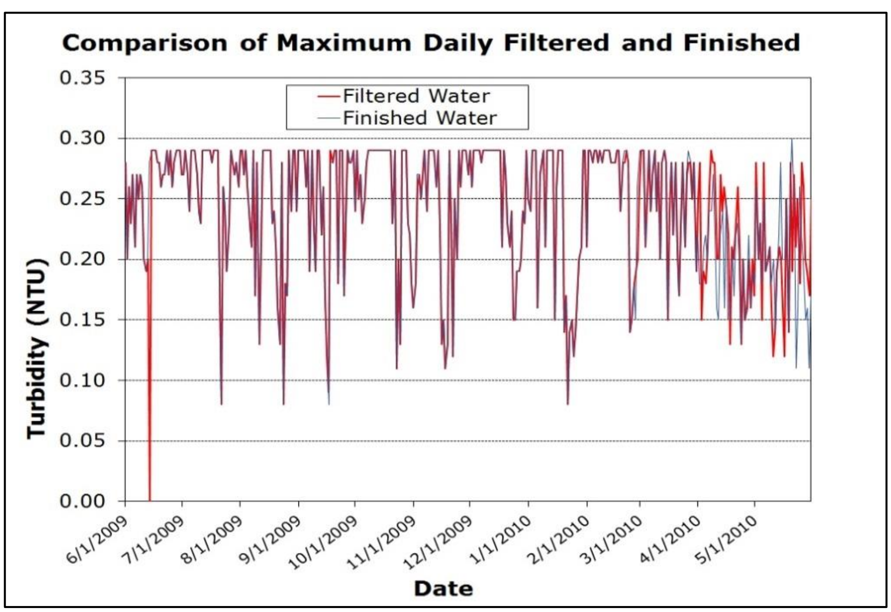


Figure 18: Comparison of "Manually Capped" IFE and CFE Turbidity Data

Example 4:

During a mCPE, the TOP assembled a number of comparison charts that displayed turbidity data which looked suspicious. One of the charts the TOP prepared, shown in Figure 17, was a comparison of the maximum daily IFE turbidity and the maximum daily CFE turbidity for an entire year. The chart shows an interesting phenomenon: when an operator is manually capping the turbidimeter data, the operator has a tendency to repeat themselves. In Figure 17, the IFE and CFE turbidity trend lines track with one another for most of the 12 months of turbidity data. This happened so often that the TOP had to format the IFE turbidity trend with a much thicker line, so that it could be seen behind the CFE turbidity line. It is also clear that the operator was capping the reported compliance data on the SWMOR, because there are many IFE and CFE peaks at 0.29 NTU.

The chief operator for this system was fired, received a criminal conviction, and was fined by the court for falsifying a government document which he had certified to be true.

Example 5:

Figure 18 shows another comparison of the IFE turbidimeter data log and the information reported on the plant's SWMOR. In this instance, there was no SCADA system, per se, and the data logged on the plant's computer was not available because of a mysterious computer crash. After the crash, the data logger was never set up to record plant performance data. Even so, the turbidimeter data logs were still intact and the TOP downloaded these data during the mCPE triggered by the confirmed IFE turbidity readings recorded for January and February 2010.

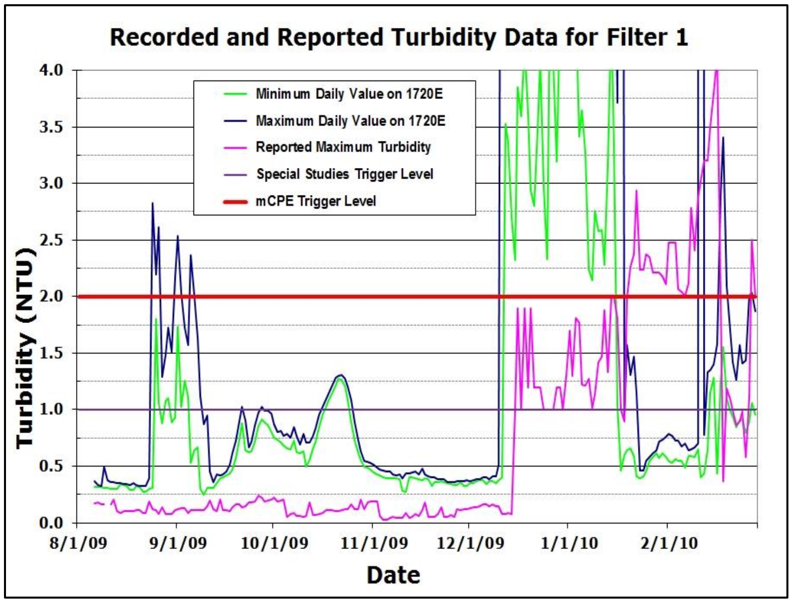


Figure 19: Comparison of Turbidimeter Data Files and IFE Turbidity Data Reported on the SWMOR

In the example shown in Figure 18, in mid-February, the information reported on the SWMOR was much higher than previously, but the IFE turbidity reported was still less than the minimum turbidity recorded in the turbidimeter log. In mid-January, the operators reported to the mayor that they had been falsifying the SWMORs and, together, they decided that they would begin reporting the data their instruments displayed. Unfortunately, they did not also decide that the turbidimeters had to be measuring a reliable sample stream and did not decide to restore the data logger function for turbidity data. Consequently, the following issues were noted during the mCPE:

- The operators were recording the IFE turbidity displayed on the SC100 controllers first thing in the morning for their IFE turbidity values. Recall that the IFE turbidity must be measured and logged at 15-minute intervals. Because they knew that they were not using a complete data set, the operators estimated what they thought a more complete record would reflect, and their estimates included multiple excursions above 2.0 NTU, which triggered the mCPE. In February 2010, the operators began reporting the turbidities shown on the display rather than estimating, but even this record was not consistent with the turbidimeter data log.
- Two of the sample transfer pumps serving the four IFE turbidimeters failed and the water stopped flowing to the turbidimeter sample chambers. The operators continued to use the displays on the SC100s to report IFE turbidity, even after the water had completely evaporated from one of the turbidimeters and the turbidimeter was measuring scattered light passing through a film that had accumulated on the sensor.

The chief operator had admitted falsifying data on the SWMORs. Both operators quit working for the City, the plant was closed, and now the City purchases water from another system.

Example 6:

During another mCPE, the team observed that the operators at the Water Treatment Plant (WTP) measured and recorded the turbidity of the raw, settled, filtered, and finished

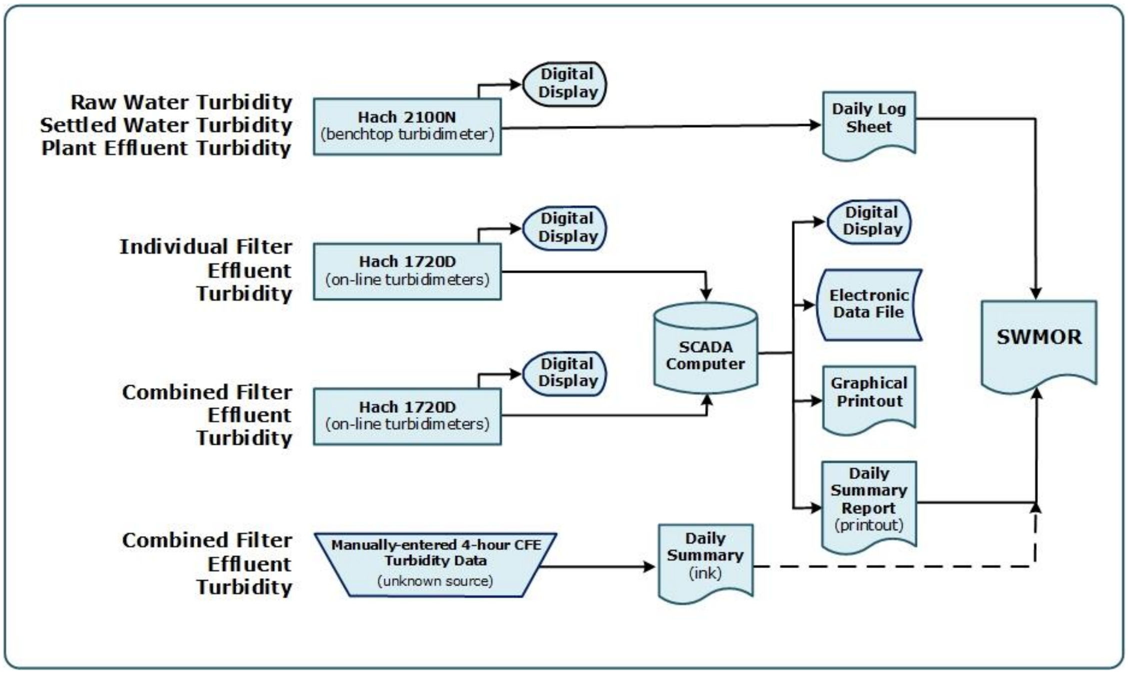


Figure 20: Data Flow from Instruments to the SWMORs

water using a combination of on-line turbidimeters and grab samples.

- The TOP team found too many data management problems to list here, but, note from Figure 18 that for some data streams, there are multiple paths from the instruments collecting the turbidity data to the SWMORs. Table 2 presents the six 4-hour CFE turbidity data for five days during the 12-month evaluation period.

Table 2: Comparison of In-plant CFE Turbidity Data Records

Date	Data Source	1	2	3	4	5	6
10/18/2007	Digital Readout[1,2]	1.86	1.66	1.87	2.17	1.76	1.43
	Graphical Printout[1,3]	0.7	0.7	0.7	0.7	0.6	0.6
	Daily Summary Printout	2.075	1.799	1.654	1.74	1.146	0.996
	Daily Summary Handwritten[4]	0.25	0.19	0.18	0.17	0.11	0.16
	SWMOR	0.25	0.19	0.18	0.17	0.11	0.16
11/12/2007	Digital Readout[1,2]	0.33	0.32	0.33	0.37	0.34	0.3
	Graphical Printout[1,3]	0.4	0.3	0.4	0.4	0.4	0.3

	Daily Summary Printout	0.315	0.336	0.431	0.412	0.608	1.056
	Daily Summary Handwritten[4]	0.03	0.03	0.04	0.04	0.06	0.11
	SWMOR	0.03	0.03	0.04	0.04	0.06	0.11
12/21/2007	Digital Readout[1,2]	0.32	0.31	0.4	0.34	0.33	0.31
	Graphical Printout[1,3]	0.2	0.2	0.1	0.1	0.1	0.1
	Daily Summary Printout	0.22	0.226	0.357	1.041	0.243	0.274
	Daily Summary Handwritten[4]	—	—	—	—	—	—
	SWMOR	0.03	0.04	0.07	0.16	0.06	0.05
1/3/2008	Digital Readout[1,2]	0.66	0.75	0.83	0.86	0.81	0.76
	Graphical Printout[1,3]	0.1	0.1	0.1	0.1	0.1	0.1
	Daily Summary Printout	0.767	0.773	0.696	0.403	0.519	0.56
	Daily Summary Handwritten[4]	—	—	—	—	—	—
	SWMOR	0.07	0.04	0.04	0.06	0.06	0.04
4/15/2008	Digital Readout[1,2]	0.645	0.626	2.012	1.558	1.13	0.937
	Graphical Printout[1,3]	0.7	0.7	2	1.5	1.2	0.9
	Daily Summary Printout[5]	0.768	0.768	0.768	0.768	0.768	0.768
	Daily Summary Handwritten[4]	—	—	—	—	—	—
	SWMOR	0.65	0.63	2	1.55	1.21	0.91

Notes:

1. Data for readings 1 - 6 represents the readings at 0000, 0400, 0800, 1200, 1600, and 2000 hours, respectively.
2. The graph is labeled "CFE" but the SCADA ModBus (the data source for the digital readout) is titled "East Clarifier”.
3. Using the graphical printout, the mCPE team was only able to determine CFE turbidity values to a precision of approximately 0.1 NTU.
4. The mCPE team could not determine the source of the handwritten entries on the Daily Summary Printout for 10/18/07 or 11/12/07. No handwritten data entries were recorded on the Daily Summary Printout for December 21, 2007, January 3, 2008, or April 15, 2008.
5. The six CFE values shown on the Daily Summary Printout for April 15, 2008 were all identical.

- Table 2 shows that some of the data sets moved independently of each other and that, until the April 15, 2008 date shown in the table, the CFE reported on the SWMOR was always a value that indicated compliance, but the only record agreeing with the SWMOR was a daily report created from an unknown source. As it happens, once the chief operator was terminated by the City, the file from the unknown source was no longer assembled and the system began reporting the CFE turbidity values from the system’s digital files on the SWMOR.

Collecting and Recording Accurate Turbidity Data:

The science behind the function of a turbidimeter has much more to do with the way the instrument is designed, the specifications for the instrument and the way the instrument interacts with the controller. Of much greater importance to the operator, are the installation and operations guidance in the turbidimeter operator's manual and the regulations and guidance spelled out in the 30 TAC Chapter 290 regulations and RG211. Specific turbidimeter operation and management that are commonly overlooked are as follows:

EPA approved methods - The turbidimeter must use an EPA approved method if the instrument is used to obtain and report compliance data.

- There are some turbidimeter technologies that are accepted in other countries, but the meters do not have the same response to particles in water as those that use EPA approved methods.
- EPA regulations are based on public health statistics assembled and compared with turbidimeter data collected by instruments with a known response. Therefore, in order to apply the regulations consistently, all compliance data collected at a SWTP must be obtained with instruments using an EPA approved method.
- EPA-approved "on-line" methods include:
  - EPA 180.1 (tungsten light bulb, 400 – 600 nm sensor)
  - Great Lakes Instrument Method 2 (LED)
  - FilterTrak Method 10133 (laser)
  - AMI Turbiwell (LED)
  - Mitchell 5271 (laser)
  - Mitchell 5331 (LED)
- Instruments that use the ISO 7027 method (a method that uses a red LED) cannot be used for compliance reporting for drinking water quality.

Accuracy and precision - The turbidimeter must be as precise and as accurate as necessary to reflect the true quality of the water being evaluated. (See Regulatory Guide (RG) 211, Section 7 for guidance on this issue.)

Proper turbidimeter installation - The turbidimeter must be installed correctly and properly maintained to ensure proper function. (See the Operations Manual for your instrument.)

Transmitter settings - The turbidimeter and controller settings must be adjusted to accurately collect turbidity data in a range wide enough to demonstrate compliance and successful treatment. (See 30 TAC §290.111(e)(3) for guidance on this issue.)

Calibrations - The turbidimeter must be properly calibrated at intervals specified by the manufacturer or by TCEQ regulations, whichever is stricter. (See the Operations Manual for your instrument and 30 TAC §290.46(s)(2)(B) for guidance on this issue.)

Performance confirmations - The turbidimeter must be confirmed to be performing accurately at specified intervals between calibrations, as specified by the manufacturer or the TCEQ, whichever is stricter. (See the Operations Manual for your instrument and 30 TAC §290.46(s)(2)(B) for guidance on this issue.)

Synchronization with the SCADA system - For on-line turbidimeters, the data record maintained by a SCADA system:

- Must be within 0.05 NTU of the reading on the display for the calibrated turbidimeter.
- If a chart recorder is used to maintain turbidity data, the operator must be able to determine the turbidity at 15-minute intervals and must be able to determine the turbidity level within 0.05 NTU of the reading on the on-line instrument. (See RG-211, Section 7 for guidance on this issue.)
- The date and time settings for the turbidimeter and the SCADA system should be the same to ensure parallel records.

Representative samples - For grab samples, the sample tap, must allow the operator to collect a representative sample. For online turbidimeters, the sample transfer line must deliver a representative sample stream to the instrument as a rate defined as acceptable by the instrument manufacturer. (See the Operations Manual for your instrument, RG-211, Section 3; and 30 TAC §290.111(e)(3) for guidance on this issue.)

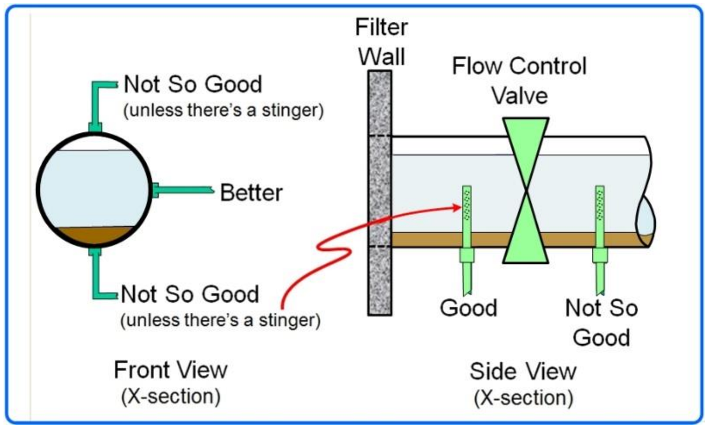


Figure 21: Guidance for Installation of Sample Taps for On-line Turbidimeters

- For a raw water sample to be representative, it must be collected from the raw water transfer line, prior to addition of any chemical treatment. If backwash waste and or sedimentation basin wastes are recycled, the raw water turbidity sample must be collected upstream of the recycle line.
- For the settled water sample to be representative, it must be collected prior to filtration. Ideally, it should also be collected prior to addition of other chemicals to the settled water.
- For the IFE turbidity samples to be representative, they must be collected prior to confluence with other IFE streams from the other filters. Additionally, the taps must be installed per the turbidimeter manufacturer's recommendations (see Figure 20). This includes using a sample quill (stinger) to collect the sample from the center of the flow stream, and avoiding installation of the sample collection point downstream of devices that will draw air from the water by reducing the water pressure.
- For the CFE sample to be representative, the sample must be collected prior to the clearwell, unless the system has an exception granting that the sample can be collected downstream of the clearwell. (See RG-211, Subsection 3.1, Page 3-5.)

Turbidity measurement timings - CFE turbidity and IFE turbidity must be collected at the intervals specified in 290.111 and RG-211, Chapter 3. If the filter is not sending water to the clearwell at a measurement interval, the IFE turbidity should be excluded from the compliance record. If the plant is idle for an entire measurement interval, no CFE is recorded for that period. If the plant is active and sending filtered water to the clearwell during a portion of the measurement interval, follow the guidelines in RG-211, Subsection 3.1 to determine the correct CFE turbidity value to report.

Confirmed readings –

- IFE turbidity measurements above 1.0 NTU must be confirmed by a second consecutive 15-minute turbidity reading above 1.0 NTU before they become a part of the plant performance record.
- IFE turbidity measurements above 2.0 NTU must be confirmed by a second consecutive 15-minute turbidity reading above 2.0 NTU before they become a part of the plant performance record.

No "grace period" - The IFE turbidity measurements logged by a calibrated turbidimeter and recorded by a synchronized SCADA system, or properly adjusted strip chart recorder, are part of the plant performance data for the water system.

- There is no "grace period" during plant startup or after a filter backwash when the turbidity record does not count toward the plant performance record.
- Any time the filter is sending water to the clearwell, IFE turbidity measurements are part of the plant's IFE turbidity record.
- If the SCADA computer does not indicate when a filter or the plant is off-line, the operations log must maintain the record of idle status so that turbidity logs in the turbidimeter, SCADA files, strip charts and other hard-copy files can be amended to reflect which data is a part of the compliance record and which is not.

Abbreviated Guidance from RG211: Monthly Testing and Reporting at Surface Water Treatment Plants

In the past, there has been some confusion about the way combined filter effluent (CFE) and individual filter effluent (IFE) turbidity measurements are sampled, analyzed, recorded, and reported to the TCEQ.

- The TCEQ regulations and guidance documents are specific, and the reason for the confusion has been due to the lack of a full knowledge of the regulations and guidance.
- This appendix to the student text for this directed assistance module has been assembled so that most of the regulatory guidance in Regulatory Guide (RG) 211, entitled "Monthly Testing and Reporting at Surface Water Treatment Plants," revised May 2013, contains detailed and specific guidance pertaining to turbidimeters, turbidimeter calibration, analytical techniques, and turbidity data integrity.

While every element of surface water treatment, monitoring, and reporting is essential for protection of public health, the information contained in this appendix only includes information directly related to turbidimeter data integrity. This abbreviation is not intended to discount other information which must be collected and reported on the SWMOR.

From RG-211 – Glossary

CFE—combined filter effluent: The water produced by all of the filters at a surface water treatment plant after it has been blended.

- The CFE is the combined water from the individual-filter-effluent (IFE) streams.
- At most plants, CFE measurements are conducted on the water entering the clearwell.
- At plants with more than one clearwell fill line, the samples may need to be collected at the outlet of the clearwell.
- A plant must obtain TCEQ approval to use a CFE turbidity monitoring point that is not located on the clearwell fill line.
- The CFE is also frequently called "treated" or "finished" water.

CPE—comprehensive performance evaluation: An extensive analysis of the design, operation, maintenance, and administration of a surface water treatment plant that is conducted to identify the factors that are limiting the facility's ability to produce high-quality drinking water.

- A public water system may have a CPE conducted as part of a voluntary effort to improve the performance of its surface water treatment plant; these CPEs are referred to as voluntary, or optimization, CPEs (oCPEs).
- If a treatment plant has individual-filter-effluent turbidity readings that exceed 2.0 NTU for two consecutive months, we will require the water system to participate in a mandatory CPE conducted by a third party; this kind of CPE is called a mandatory, or compliance, CPE (mCPE).

- At plants that are allowed to monitor CFE instead of monitoring IFE, the exceedance is based on the turbidity level of the combined filter effluent instead of the turbidity level at the effluent of an individual filter.

Effluent: The point where water leaves a treatment unit, such as a filter.

Filter assessment: A comprehensive evaluation of design, maintenance, operation, and performance of an individual filter and its associated facilities.

Filter exceedance: In the context of this manual, a filter exceedance is an event when the water produced by an individual filter has a turbidity level above the performance goal established by the TCEQ for two consecutive 15-minute readings.

- One example of a filter exceedance is when the turbidity level in the water produced by an individual filter rises above 1.0 NTU for two consecutive 15-minute readings.
- A filter exceedance is not the same thing as a treatment-technique violation, but a severe exceedance on one or more filters may cause the plant to violate a treatment-technique requirement for treated-water turbidity levels.
- At plants that are allowed to monitor CFE instead of monitoring IFE, the exceedance is based on the turbidity level of the combined filter effluent instead of the turbidity level at the effluent of an individual filter.

Filter profile: A graph that shows the turbidity level of the water produced by an individual filter for an entire filter run and explains the cause of every event where consecutive turbidity readings change by more than 0.1 NTU.

- At plants that are allowed to monitor CFE instead of monitoring IFE, the filter profile will be prepared using the combined filter effluent monitoring point instead of the monitoring points on individual filters.

Finished water: The water leaving a treatment plant; water that has passed through all of the treatment units. Finished water is sometimes called treated water.

IFE—individual-filter effluent: The water produced by a single filter.

Individual filter: A filtration unit that has its own influent and its own effluent.

Influent: The point where water enters a treatment unit, such as a filter.

MD—missing data: The value entered in a data-entry cell when a plant collected some, but not all, of the required data needed to complete part of the report.

- For example, if the plant only collected some of the individual filter effluent turbidity data that should have been collected on a given date (and none of the readings that were collected indicate that there was a filter problem), the operators would enter <MD> in the appropriate cell.

Monitoring requirement: A test that must be run in order to meet minimum state and federal standards. For example, some of the monitoring requirements include tests for treated-water turbidity, individual filter turbidity, water temperature, and disinfectant residuals.

ND—no data: The value entered in a data entry cell when a plant failed to collect any of the required data needed to complete part of the report.

- For example, if the plant failed to measure the turbidity level of the finished water at one of the required sampling times, the operators would enter <ND> in the appropriate cell to indicate that the data point was not collected.

NTU—Nephelometric Turbidity Unit: The unit of measurement for turbidity.

Raw water: The untreated water entering a treatment plant.

Reporting month: The month during which you collected the data being reported.

Settled water: The water leaving a sedimentation basin before it passes through the filter.

Spreadsheet: An electronic file containing data that is arranged by rows and columns. In the case of the SWMOR and SWMOR2, it is an electronic file containing some of the performance data collected at a single surface water treatment plant during a single month.

Treated water: The water leaving a treatment plant; water that has passed through all of the treatment units. Treated water is sometimes called finished water.

Treatment technique requirement: A minimum level of treatment that must be achieved before the water meets minimum state and federal standards.

- Treatment technique requirements are equivalent to maximum contaminant levels (MCLs).
- However, the treatment technique requirement indirectly limits the risk posed by a specific contaminant, while the MCL limits the specific contaminant itself.
- For example, the treatment technique requirements for turbidity and disinfection have been set instead of setting MCLs for the pathogens *Cryptosporidium parvum*, *Giardia lamblia*, Legionella, and enteric viruses.

From RG211 Subsection 3.1: Enter Daily Plant-Performance Data

Raw Water Analyses

Each day, record the turbidity and the alkalinity of the raw water treated by the plant in the Raw Water Analyses column.

- Record the turbidity of the raw water in the **NTU** column.
- You must measure the turbidity and the alkalinity of the raw water at least once each day when your plant treats water.
- If you conduct more than one set of tests during the day, record the average value for each parameter.
- See Table 7.1 in Chapter 7 of this manual to find the acceptable laboratory methods for measuring these values.
- If your plant did not treat water on a specific day, enter <X> in each of the **NTU** and **Alk.** columns. If you treated water but did not collect turbidity or alkalinity data on a specific day, enter <ND> in each of the **NTU** and **Alk.** columns.

Settled Water Turbidity

If we have required your plant to monitor levels of settled water turbidity, you must do so as often as we have specified in our approval letter.

- Even if such monitoring is optional for your plant, the TCEQ recommends that you measure the turbidity of the settled water at the effluent of each sedimentation basin at least once each day.
- Data on settled-water turbidity data allows for valuable analysis of the performance of sedimentation and, in particular, the performance of each basin.
- See Table 7.1 in Chapter 7 of this manual to find the acceptable laboratory methods for measuring turbidity.

CFE Turbidity (Finished Water)

You must measure and record the turbidity of the combined filter effluent each day that your plant treats water. That means that you must record turbidity results each day that you show a raw water pumpage above 0.000 MGD.

What Test to Run: Using an acceptable method from Table 7.1, measure the turbidity of the finished water on a regular schedule.

Where to Sample: You should collect the CFE turbidity sample at the filter outlet header or the clearwell inlet line. However, the TCEQ occasionally approves other sampling sites, such as the clearwell outlet line or the service pump discharge line.

When to Sample: The timing and number of CFE turbidity readings that you must record depends on the number of people that your water system serves. The specific requirements are:

Systems Serving 500 or Fewer Persons: If your system serves 500 or fewer persons each day, you must take this reading at least once each day. The reading must be taken at the same time each day.

Systems Serving More than 500 Persons: If your system serves more than 500 persons, you must take regular four-hour readings whenever the plant is in operation. For example, you may take these readings at 2 a.m., 6 a.m., 10 a.m., 2 p.m., 6 p.m., and 10 p.m. Use the same schedule each day. You may take these readings more frequently than once every 4 hours, but you must use only the readings made at the designated times to determine whether your plant is in compliance.

The TCEQ sets six standard four-hour periods each day: NTU1 is midnight to 4 a.m.; NTU2 is 4 a.m. to 8 a.m.; NTU3 is 8 a.m. to noon; NTU4 is noon to 4 p.m.; NTU5 is 4 p.m. to 8 p.m.; and NTU6 is 8 p.m. to midnight. Readings must be taken to represent each of the TCEQ's four-hour reporting periods when the plant is producing water for any portion of the time.

- For example, if the treatment plant starts up at 7 a.m. and shuts down at 5 p.m. each day, the system must set a sampling schedule to represent the treated water for the four-hour periods from midnight to 8 a.m., from 8 a.m. to noon, from noon to 4 p.m., and from 4 p.m. to 8 p.m.
- An acceptable schedule would be to take turbidity readings at 7:30 a.m., 11:30 a.m., 3:30 p.m., and 5:00 p.m.
- The reading taken at 7:30 am would be entered in the NTU2 field; the reading collected at 11:30 am would be entered in the NTU3 field, the 3:30 reading would be entered in the

NTU4 field, and the 5:00 pm reading would be entered in the NTU5 field, right before the plant shuts down.

- Note that the interval between the last two readings in this example is less than four hours, which is acceptable in this case. However, it is never acceptable for the interval between samples to be longer than four hours.

WHEN TO SAMPLE—SPECIAL CASES

If you are using automated systems to operate or monitor your plant, there are some special requirements that you need to consider when reporting finished water turbidity data. For example:

Auto-cycling: If your plant automatically cycles off and on, we consider the plant to be in continuous operation unless you have turned off the raw water pumps with the manual override. If your plant is not treating water when the sample is supposed to be collected, you must use the last reading that was collected when the plant was in operation. The clearwell and the service pump station may, however, continue to operate when the plant is not in operation because these facilities can continue to operate even if the plant is not filtering water.

Online turbidimeters: If your plant uses a continuous turbidity analyzer, you may either take the turbidity data from the recorder chart or use the results of grab samples. If you choose to use data from the recorder chart, you must verify the accuracy of the turbidity monitor at least once each week. See Section 7.2, "Calibrating Instruments and Other Equipment," for more information about calibrating continuous turbidity monitors and recorders.

IMPORTANT

Avoid calibrating your online turbidimeters immediately before a sample collection is scheduled. If there is a problem during calibration, you could end up recording an erroneous result. Allow at least 15–20 minutes to complete a calibration procedure so that you don't end up missing a sample or accidentally reporting the value of the turbidity standard you are using.

If you do happen to be calibrating an online turbidimeter when a sample is supposed to be collected, we will allow you to report the level of finished-water turbidity using one of the following methods:

- a grab sample and benchtop turbidimeter
- the turbidity reading from the online meter that is recorded 15 minutes after the calibration process is completed
- the last turbidity reading recorded by the online turbidimeter before it was taken offline for calibration

How to Enter Results: The SWMOR contains six columns for recording the turbidity of the finished water. Each column represents a four-hour period of the day.

- For example, the NTU1 column represents midnight to 4 a.m., and the NTU6 column represents 8 p.m. to midnight.
- If your plant is in operation during any portion of the four-hour period, you must measure and record a turbidity reading and enter the result in the appropriate column.
- If your plant is offline during the entire four-hour period, enter <X> in the corresponding column.

- If the plant treated water at any time during a four-hour period but the required turbidity reading was not recorded at the required time, enter <ND> in the appropriate cell.

From RG211 Subsection 3.2: Enter Daily Data on Individual-Filter Turbidity Performance

The Filter Data area of the form is where you will summarize the performance of each of your plant's individual filters. The data on individual-filter-effluent (IFE) turbidity is entered on page 3.

- To get to page 3, click on the **P.3-Filter Data tab**.
- You must enter information on page 3 of the SWMOR every day that your plant treats water.
- You must also enter some additional information at the end of the month about the performance of individual filters during previous months.

Daily Data on Individual-Filter Performance

- The **Performance Data** table on page 3 of the SWMOR contains columns for recording the turbidity of the filtered water from Filters No. 1-10.
- If your plant has more than 10 filters, additional columns for recording the filtered water turbidity from up to 50 filters are provided on the addendum pages.

Readings of Individual-Filter Turbidity

- You must measure and record the turbidity of the water produced by a filter whenever it is sending water to the clearwell.
- That means that you must record at least one result for IFE turbidity for each day when you show a raw-water pumpage above 0.000 MGD.

What Test to Run: You must use one of the acceptable methods from Table 7.1 to measure the turbidity of the water produced by each filter.

Where to Sample: You must collect the IFE turbidity sample at the outlet of each filter before that water is mixed with the water from any other filter.

When to Sample: You must record the IFE turbidity reading every 15 minutes whenever the filter is sending water to the clearwell. These readings must be collected on the quarter hour, for example, at 1:00 p.m., 1:15 p.m., 1:30 p.m., and 1:45 p.m.

- The calibration of each continuous turbidity monitor must be verified at least once each week. See Section 7.2, "Calibrating Instruments and Other Equipment," for information about calibrating the online monitors and recorders.
- A plant that experiences a failure in the continuous monitoring equipment may collect grab samples every 4 hours for no more than 5 working days.
- If the result of a grab sample is greater than 1.0 NTU, the plant must collect a confirmation sample 15 minutes later.

SPECIAL CASE—FILTER TO WASTE

A filter is in operation when it is discharging water that contributes to the combined filter effluent. A filter is not in operation if it is offline or filtering to waste.

IMPORTANT

Avoid calibrating your online turbidimeters immediately before a sample is scheduled to be collected. If there is a problem during the calibration procedure, you could end up recording an erroneous result. If you have a calibration problem that affects two consecutive 15-minute readings, you must either document that these readings were collected during a calibration procedure or you will need to fill out a filter-profile report as described in chapter 4.

How to Enter Results: For each filter, record the maximum turbidity value that you recorded in the corresponding **Max** column.

- If you recorded the turbidity level four hours after starting a filter run, enter that data in the **4 Hrs** column.
- If a filter is not in operation on a specific day, enter <X> in both the **Max** and **4 Hrs** columns.
- If you were not required to collect a 4-hour reading, enter <X> in the **4 Hrs** column.

Maximum IFE Turbidity

Record the maximum turbidity value from each filter in the corresponding Max column.

- If a filter is not in operation on a specific day, enter <X>. (See the **important note** below and Examples 3.7 and 3.8 that follow.)
- If you collected none of the required IFE 15-minute turbidity readings for a particular filter, you must enter <ND> in the applicable **Max** cell.
- If you recorded some, but not all of the required 15-minute readings, then you must: enter the highest reading of the day if it was above 1.0 NTU

or

- enter <MD> if you recorded some, but not all of the required readings, but all of the readings that you have were 1.0 NTU or less.

IMPORTANT

Systems may be required to conduct additional monitoring if the turbidity level from a filter exceeds the 1.0 NTU or 2.0 NTU trigger level in two consecutive 15-minute readings. Do not report any turbidity reading above either trigger level unless a filter exceeds the trigger level in two consecutive 15-minute readings.

If the turbidity level from a filter is greater than 2.0 NTU on a specific day, report the highest reading only if the reading collected 15 minutes before or after is also greater than 2.0 NTU. If the turbidity level is greater than 1.0 NTU, report the highest reading only if the preceding or following 15-minute reading is also greater than 1.0 NTU. If the turbidity level does not exceed either trigger level in two consecutive 15-minute readings, report the maximum reading no greater than 1.0 NTU.

IFE Turbidity at 4 Hours

If your system serves fewer than 10,000 persons each day, you may leave the 4 Hrs columns blank.

If your system serves 10,000 or more persons, in the corresponding 4 Hrs column, record the turbidity value from each filter at the end of four hours of continuous filter operation after the filter is returned to service from backwash or shutdown**.**

- If such an event occurs more than once for a filter during the day, enter the reading for the event with the maximum turbidity level at four hours.
- If no such event occurs for a filter on a specific day, enter <X>.
- If you failed to record required 4-hour turbidity readings for a particular filter, you must enter <ND> in the applicable 4 Hrs cell.
- If you recorded some, but not all of the required readings on a given day, then you must:
- enter the highest reading of the day if any of the 4-hour readings that you do have were above 0.5 NTU

or

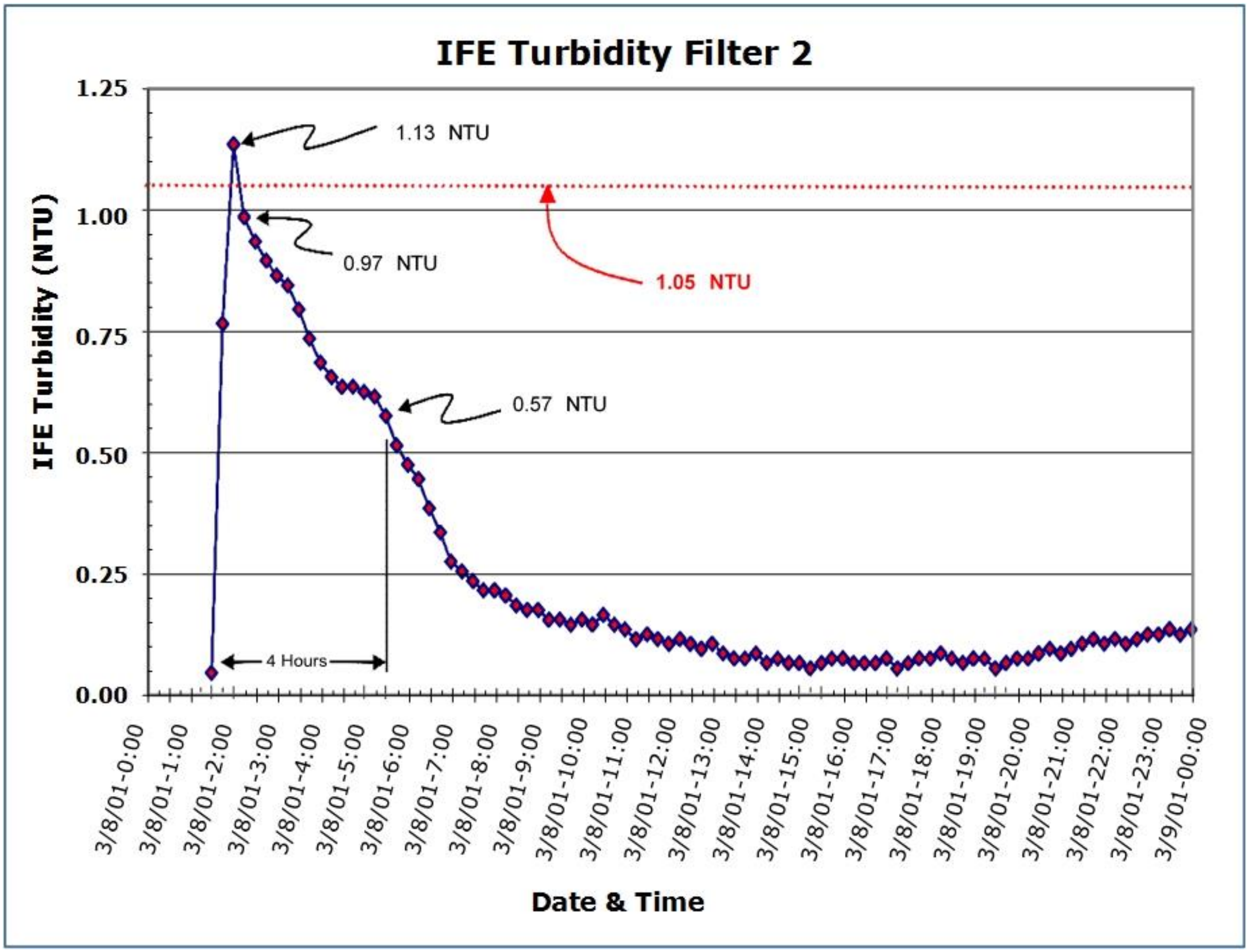
- enter <MD> if you recorded some, but not all of the required readings, but all of the readings that you do have were 0.5 NTU or less.

IMPORTANT

Systems serving fewer than 10,000 people are not required to report “4-hour” data. However, the SWMOR spreadsheet allows you to report the data if you wish. If you decide to include the data, the SWMOR spreadsheet will calculate the number of days when the **4 Hrs** column contains readings above 0.5 NTU but it automatically excludes the information when determining whether additional monitoring is required. Thus, there are no negative consequences to including the additional information.

Systems serving 10,000 or more persons may be required to conduct additional monitoring if the turbidity level from a filter exceeds 0.5 NTU in two consecutive 15-minute readings at the end of four hours of continuous filter operation. Do not report any turbidity reading above 0.5 NTU unless a filter exceeds 0.5 NTU in two consecutive 15-minute readings at the end of four hours into a filter run. If the turbidity level from a filter is greater than 0.5 NTU at 4 hours, report that reading only if the preceding reading, that is, the reading at 3 hours 45 minutes, or the following reading—that is, the reading at 4 hours, 15 minutes—is also greater than 0.5 NTU. Otherwise, report the subsequent reading, that is, the reading at 4 hours, 15 minutes.

Example 3.6: Maximum Daily and 4-Hour Individual Filter Effluent Turbidity The following figure shows the turbidity readings on samples collected at the effluent of Filter No. 2.



Filter No. 2 was backwashed the previous day and allowed to sit idle for three hours to pre-ripen. It was returned to service at 1:20 a.m. Since turbidity readings must be collected on the quarter hour, the first turbidity reading of the filter run occurs at 1:30 a.m.

Although the maximum daily turbidity reading from this filter was 1.13 NTU, the value was not confirmed by a second consecutive reading of 1.05 NTU or higher. Consequently, when completing page 3 of the SWMOR, the operator should record the 0.97 NTU reading in the **Max** space for March 8, 2001.

At 5:30 a.m., four hours after the first turbidity reading, the operator records a turbidity level of 0.57 NTU. Since this reading is above 0.50 NTU, the operator checks the readings at 5:15 and 5:45 a.m. to determine if at least one of those is also above 0.50 NTU. Since the reading at 5:15 is 0.55 NTU or higher, the operator records the 0.57 NTU reading in the **4 Hrs** space on the SWMOR.

Example 3.7: IFE Turbidity

A surface water treatment plant submits an SWMOR containing the following data:

PERFORMANCE DATA														
	INDIVIDUAL FILTER TURBIDITY													
	Filter No. 1		Filter No. 2		Filter No. 3		Filter No. 4		Filter No. 5		Filter No. 6		Filter No. 7	
Date	Max	4 Hrs	Max	4 Hrs	Max	4 Hrs	Max	4 Hrs	Max	4 Hrs	Max	4 Hrs	Max	4 Hrs
1	0.52	X	0.66	0.11	0.93	0.17	0.33	X	0.45	X	0.34	X		
2	0.40	0.14	0.35	0.30	ND	ND	0.86	0.37	0.78	0.28	X	X		
3	0.23	ND	0.65	X	MD	0.22	0.27	X	0.31	X	0.45	0.09		
4	1.60	0.57	0.73	0.09	0.43	X	0.59	0.19	1.10	ND	0.26	X		
5	X	X	X	X	X	X	X	X	X	X	X	X		

The individual filter turbidity data gives us this information—

1. On the first day of the month:
   a. All six of the plant's filters were operated for some period of time.
   b. There are no 4-hour readings required for Filters No. 1, 4, 5, and 6. Consequently, they were either operated all day long or they were taken offline at some point during the day and were not restarted.
   c. Filters No. 2 and 3 were either taken offline or backwashed at least once during the day. The filters were then restarted and operated for a period of at least four hours.
2. On the second day of the month:
   a. No data was recorded for Filter No. 3.
   b. Filter No. 6 was not operated at all that day.
3. On the third day of the month,
   a. Filter No. 1 was taken out of service, backwashed, and then restarted at least once during the day. However, the operator did not record the turbidity level of the water four hours after beginning one of the production runs.
   b. The SCADA system failed to record all of the required 15-minute IFE turbidity readings from Filter No. 3. However, we know that none of the readings that were recorded were above 1.0 NTU (because, otherwise, the operator would have recorded the exceedance).
4. On the fourth day of the month:

a. The turbidity level from Filters No. 1 and 5 exceeded 1.0 NTU in two consecutive 15-minute readings.

b. The turbidity level from Filter No. 1 exceeded 0.5 NTU in two consecutive 15-minute readings at four hours after the filter was returned to service.

c. The SCADA system failed to record the turbidity level produced by Filter No. 5 four hours after it began a filter run.

5. The plant was completely offline on the fifth of the month; the raw-water flow rate on page 2 of the SWMOR will be 0.00 MGD. (Note: The SWMOR will not let you enter Xs in all the filters unless the flow rate is 0.00 MGD.)

6. If the water system serves at least 10,000 people, the missing 4-hour turbidity readings on the first four days of the month will each result in a monitoring and reporting violation because these systems are required to collect this data. If the system serves fewer than 10,000 people, it is not required to collect this data and so the SWMOR will not treat the empty spaces as data-entry errors.

Summary and Compliance Actions (Page 3 of the SWMOR)

The **Summary and Compliance Actions** table at the bottom of page 3 of the SWMOR contains columns for summarizing the historical performance of Filters No. 1–10. If your plant has more than 10 filters, additional columns for recording the IFE turbidity data turbidity for up to 50 filters are available on the addendum pages. Figure 3.4 shows the portion of the SWMOR that is described in this portion of the guidance manual.

SUMMARY & COMPLIANCE ACTIONS	Criteria	Filter No. 1	2	3	4	5	6	7
	Number of days with event(s) above 0.5 NTU at 4.0 hrs this month							
	Number of days with event(s) above 1.0 NTU this month							
	Number of days with event(s) above 1.0 NTU last month							
	Number of days with event(s) above 1.0 NTU two months ago							
	Total number of days with event(s) above 1.0 NTU in three months							
	Number of days with event(s) above 2.0 NTU this month							
	Number of days with event(s) above 2.0 NTU last month							
	Does the filter/plant have an approved Corrective Action Plan?							
	Is the plant required to submit a Filter Profile Report?							
	Is the plant required to submit a Filter Assessment Report?							
	Is the plant required to submit a Request for Compliance CPE?							

Figure 3.4. Summary & Compliance Actions section on page 3 of the SWMOR.

After you review the information on the following several pages, Example 3.8 illustrates how to complete and interpret the information contained in this portion of the SWMOR.

Number of days with event(s) above 0.5 NTU at 4.0 hours this month

For each filter at the plant, the SWMOR counts the number of days when you entered a turbidity reading above 0.5 NTU in the **4 Hrs** column.

Number of days with event(s) above 1.0 NTU this month

For each filter at the plant, the SWMOR counts the number of days when you entered a turbidity reading above 1.0 NTU in the **Max** column.

Number of days with event(s) above 1.0 NTU last month

For each filter at the plant, record the number of days during the last reporting month that you entered a turbidity level above 1.0 NTU. Pull this information from the row of last month's SWMOR labeled **Number of days with event(s) above 1.0 NTU this month**.

Number of days with event(s) above 1.0 NTU two months ago

For each filter at the plant, record the number of days that you entered a turbidity level above 1.0 NTU during the reporting period two months ago. If you pull this information from the row of last month's SWMOR labeled **Number of days with event(s) above 1.0 NTU last month**, you will not have to look at the SWMOR from two months before.

Total number of days with event(s) above 1.0 NTU in three months

For each filter at the plant, the SWMOR calculates the total number of days that you entered a turbidity level above 1.0 NTU during the last three reporting months.

Number of days with event(s) above 2.0 NTU this month

The SWMOR analyzes the data that you entered for each filter at the plant and determines how many days there were with at least one turbidity reading above 2.0 NTU in the **Max** column.

Number of days with event(s) above 2.0 NTU last month

Record the number of days during the last reporting month that you entered one or more turbidity reading values above 2.0 NTU. Pull this information from the **Number of days with event(s) above 2.0 NTU this month** row of last month's SWMOR.

Does the filter/plant have an approved corrective action plan?

For each filter at the plant, use the drop-down list to indicate whether we have approved a corrective-action plan (CAP) that waives the additional monitoring requirements for a specific filter. If the filter has an approved CAP, select <Y>. If the filter does not have an approved CAP, select <N>.

Also use the drop-down list for the plant to show whether we have approved a CAP that waives the plant from the requirement to participate in a comprehensive performance evaluation.

IMPORTANT

You do not have an approved corrective-action plan unless we have written you a CAP-approval letter. These approval letters:

- identify the specific filters or plant that is covered by the approved CAP
- briefly describe the corrective actions that must be completed
- establish a compliance schedule for implementing the improvements

Once the improvements are complete, the CAP expires and the approval letter is no longer valid.

We generally do not approve a CAP for an individual filter unless the plant has submitted a filter-assessment report (FAR) and proposed CAP on that specific filter. If you have not conducted and submitted an FAR for the filter, you probably do not have an approved CAP for that filter.

We generally do not approve a CAP for the plant unless the system has participated in a CPE that was conducted by the TCEQ or a third party.

Is the plant required to submit a Filter Profile Report?

For each filter at the plant, the SWMOR determines if the plant is required to conduct any filter profile on the filter and submit one or more filter-profile reports with the SWMOR.

IMPORTANT

Unless a filter has an approved corrective-action plan that waives the filter from additional monitoring requirements, you must either identify the cause of exceedance or produce a filter profile on the filter each time that the IFE turbidity level in the water produced by that filter exceeds 1.0 NTU in two consecutive 15-minute readings.

If your system serves 10,000 people or more, you must also identify the cause of exceedance or produce a filter profile each time that the IFE turbidity level exceeds 0.5 NTU in two consecutive 15-minute readings at four hours after the filter is returned to service.

Is the plant required to submit Filter Assessment Report(s)?

For each filter at the plant, the SWMOR determines if the plant is required to conduct any filter assessment on the filter and submit one or more filter-assessment reports with the SWMOR.

IMPORTANT

Unless a filter has an approved corrective-action plan that waives the filter from additional monitoring requirements, you must conduct an assessment on it each time that a filter exceeds 1.0 NTU in two consecutive 15-minute readings on three separate occasions during the last three reporting months.

Is the plant required to submit a CPE Request Form?

The SWMOR determines if the plant is required to participate in a third-party CPE and submit a request-for-compliance CPE with the SWMOR.

IMPORTANT

Unless the plant has an approved corrective-action plan that waives the CPE requirement, you must participate in a third-party CPE each time that a filter or any combination of filters exceeds 2.0 NTU in two consecutive 15-minute readings during the last two reporting months.

Example 3.8: Individual Filter Effluent Summary & Compliance Section

This figure includes the **Summary and Compliance Action** areas of the June and July 2002 SWMORs for a treatment plant in Texas.

July 2012 (This month's SWMOR)

SUMMARY & COMPLIANCE ACTIONS

Criteria	Filter No. 1	2	3	4	5	6	7	8	9	10	Plant
Number of days with event(s) above 0.5 NTU at 4.0 hrs this month	0	0	0	1							
Number of days with event(s) above 1.0 NTU this month	1	0	0	0							
Number of days with event(s) above 1.0 NTU last month	1	1	2	0							
Number of days with event(s) above 1.0 NTU two months ago	1	1	1	0							
Total number of days with event(s) above 1.0 NTU in three months	3	2	3	0							
Number of days with event(s) above 2.0 NTU this month											0
Number of days with event(s) above 2.0 NTU last month											1
Does the plant have an approved corrective action schedule?	N	N	Y	N							N
Is the plant required to submit a Filter Profile Report?	Y	N	N	Y							
Is the plant required to submit a Filter Assessment Report?	Y	N	N	N							
Is the plant required to submit a Request for Compliance CPE?											N

June 2012 (Last month's SWMOR)

SUMMARY & COMPLIANCE ACTIONS

Criteria	Filter No. 1	2	3	4	5	6	7	8	9	10	Plant
Number of days with event(s) above 0.5 NTU at 4.0 hrs this month	0	0	0	0							
Number of days with event(s) above 1.0 NTU this month	1	1	2	0							
Number of days with event(s) above 1.0 NTU last month	1	1	1	0							
Number of days with event(s) above 1.0 NTU two months ago	0	0	0	0							
Total number of days with event(s) above 1.0 NTU in three months	2	2	3	0							
Number of days with event(s) above 2.0 NTU this month											1
Number of days with event(s) above 2.0 NTU last month											0
Does the plant have an approved corrective action schedule?	N	N	Y	N							N
Is the plant required to submit a Filter Profile Report?	Y	Y	N	N							
Is the plant required to submit a Filter Assessment Report?	N	N	N	N							
Is the plant required to submit a Request for Compliance CPE?											N

This example shows that:

1. You can use the preceding month's SWMOR to help you complete the information in these rows:
   - **a.** Number of days with events above 1.0 NTU last month,
   - **b.** Number of days with events above 1.0 NTU two months ago, and
   - **c.** Number of days with events above 2.0 NTU last month.

2. You will need to submit a Filter Profile Report on Filters No. 1 and 4 with the July SWMOR because:
    a. there was one day when the maximum turbidity reported on Filter No. 1 was above 1.0 NTU,
    b. there was one day when the turbidity level on Filter No. 4 was above 0.5 NTU exactly four hours after it was placed online, and
    c. we have not yet approved a CAP on either of the filters.
3. You will need to submit a filter-assessment report on Filter No. 1 because the maximum turbidity level exceeded 1.0 NTU on a total of at least three days during the past three months and it has no approved CAP.
4. You have an approved CAP for Filter No. 3 and so you didn't have to submit a filter-assessment report on that filter in June (even though there was a total of three days when the turbidity level rose above 1.0 NTU).
5. You don't need to submit a filter-assessment report on Filter No. 3 in July for two reasons:
    a. you have an approved corrective action plan on the filter, and
    b. none of the three readings above 1.0 NTU occurred during the month of July.

From RG211 Section 7: Analytical Methods

Introduction

To ensure that the water you produce is safe for drinking, your plant must be able to accurately measure several important performance parameters. The parameters include:

- the flow rate of the raw and treated water
- the turbidity level of the raw, settled, IFE, and CFE waters
- the total organic carbon level of the raw and CFE waters
- the temperature in each disinfection zone
- the pH in each disinfection zone
- the disinfectant residual at the end of each disinfection zone
- the disinfectant residual leaving the plant
- the disinfectant residual in the distribution system

If you are using innovative treatment like membranes or ultraviolet light disinfection, you may be required to analyze additional parameters.

Because performance monitoring is so important to public health protection, we require you to develop a monitoring plan for your plant and its distribution system.

- We also require that you submit a copy of this plan for our review and approval, and send us a copy of any revisions that you make to the plan.
- Since every public water system in Texas is required to develop this plan, we have published a separate guidance document entitled *How to Develop a Monitoring Plan for a Public Water System* (TCEQ publication RG-384).
- Please call 512-239-4691 or e-mail <PWSCHEM@tceq.gov> to obtain copies of this and other TCEQ publications.

All testing to meet our minimum monitoring and reporting requirements must be performed at a laboratory that we approve.

- In order to get your laboratory approved, you must use one of our approved methods to run each test, your equipment must be properly calibrated and maintained, and you must use proper laboratory techniques and maintain acceptable records.

Acceptable Analytical Methods

- In order to maintain consistency throughout the state, we are requiring that you use certain methods to conduct your turbidity, temperature, pH, and disinfectant residual tests. The approved methods are shown in Table 7.1 and 7.2.
- Tables 7.1 and 7.2 also list examples of commercially available test kits or lab equipment. These lists are not all-inclusive. If you find that a commercial product we have listed here is no longer available, ask the manufacturer which products would offer the same sensitivity.

Table 7.1. Acceptable laboratory methods for measuring turbidity, temperature, and pH.

Parameter	**Minimum Accuracy**[a]	**Acceptable Methods**[b]	Examples of Commercial Test Kits or Equipment[c]
Turbidity	± 0.05 NTU	Nephelometric (SM 2130 B) Nephelometric (EPA 180.1)	Hach 2100N and 2100AN HF Scientific Micro 100 and Micro 1000 Hanna HI88703 Orion AQ4500 Hach 1720D or E (online monitors) HF Scientific MicroTol (online monitor) LaMotte 2020 ClearTrace (online monitor)
		Great Lakes Instruments Method 2	Great Lakes Accu4 (online monitor) Orion AQ4500
		AMI Turbiwell	Swan AMI Turbiwell with LED (online monitor)
		Mitchell M5331	
		Orion AQ4500	Orion AQ4500
	± 50 mNTU	Hach FilterTrak Method 10133	Hach FilterTrak 660 (online monitor)
		Mitchell M5271	(online monitor)

[a] This value is the minimum accuracy needed to comply with TCEQ requirements. The value shown may differ from the value in the EPA's *Standard Methods* (see following note) or EPA procedures.

[b] SM—*Standard Methods*, 22nd Edition; EPA—EPA methods.

[c] This is neither a complete list of all commercially available test kits nor an endorsement of any specific product.

Calibrating Instruments and Other Equipment

Before you can effectively use your performance data, it must be accurate.

- One of the most important ways to ensure this accuracy is to keep your instruments and equipment properly calibrated and maintained. Consequently, we have established some minimum calibration requirements for lab equipment and flowmeters.

Primary Calibration of Turbidity Meters

Once every three months, you must calibrate your turbidimeter in accordance with the manufacturer's directions.

- This quarterly calibration must be conducted using primary turbidity standards.
- If you are using a benchtop turbidimeter, you must restandardize your secondary standards each time that you calibrate the unit with primary standards.

If you are using a benchtop turbidimeter to collect data that you report to the TCEQ, you must check its calibration with a primary or secondary standard each time that you run a series of samples.

- If the unit is not giving an accurate reading, you must recalibrate it with primary standards.

If you are using online turbidimeters to collect data that you report to the TCEQ, you must also check the calibration of your turbidimeter once per week using a primary or a secondary standard, the manufacturer's proprietary calibration device, or by using the following procedure:

1. Check the calibration of the bench-scale turbidity meter with a primary or secondary standard.
2. Record the turbidity reading shown on the online monitor.
3. Collect a sample from the inlet or outlet of the online monitor.
4. Measure and record the turbidity of the sample from the online monitor.
5. Compare the turbidity readings from the two instruments.
   a. If the values differ by more than 0.10 NTU:*
      i. Follow the manufacturer's instructions and recalibrate both the online and bench turbidimeters using primary turbidity standards.
      ii. Repeat Steps 1–6. If the values still differ by more than 0.10 NTU,* contact the instrument's manufacturer for further instructions.
   b. If the values differ by no more than 0.10 NTU,* complete calibration of the units is not required.
6. If a continuous recorder is used, compare the value reported by the recorder with the value reported by the monitor.
   a. If the values differ by more than 0.05 NTU,* adjust the recorder.
   b. If the values differ by 0.05 NTU,* or less, no adjustment of the recorder is needed.

* If the comparison is conducted when turbidity levels are above 1.0 NTU, you may accept differences of up to 10% when comparing the results of two turbidimeters and of up to 5% when comparing the recorder results with that of the turbidimeter.

Regardless of which method you use to check the calibration of the online turbidimeter, you must recalibrate the unit using primary standards if the unit is not providing an accurate reading.

Rounding Numbers on Your SWMOR

Your plant can probably measure water quality data to a very high level of precision. However, we do not want the SWMOR or SWMOR2 to show so many decimal places that we cannot read the report. Still, you should probably record as many decimal places as possible on your daily log, and you may enter as many digits as you can when entering data in the two spreadsheets.

To ensure that we can read the form when you submit it, the SWMOR and SWMOR2 are both designed to automatically round any value you enter to the proper number of decimal places. Don't be surprised if your spreadsheet doesn't show or print all of the decimal places that you entered when you filled out the report. Table 7.3 shows how the two spreadsheets round the values that you enter.

The two spreadsheets also do some additional rounding when they perform some of their automatic determinations. For example, if you enter a reading for filtered-water turbidity of <0.346> NTU, your report will display and print a reading of 0.35 NTU, but it will not count the reading as being above 0.3 NTU, since the actual value that you entered was not higher than 0.35 NTU. Therefore, it is beneficial to enter actual results and let the spreadsheet program do all the rounding for you.

	The Reports Round to Nearest …	Examples		
		Entered Value	Displayed Value	
Raw-water turbidity	1 NTU	124.3 75.834	124 76	
Settled-water turbidity	0.1 NTU	3.43 1.856	3.4 1.9	
Filtered-water turbidity	0.10 NTU	0.544 0.546 1.044 1.046 2.043 2.053	0.54 0.55 1.04 1.05 2.04 2.05	For values less than 0.1, round to the nearest 0.01 NTU. For values that exceed a trigger level, the SWMOR counts only those values that are above that trigger level based on the value you entered and after rounding—not the values displayed.
Treated water turbidity	0.1 NTU	0.349 0.350 1.049 1.050	0.3 0.4 1.0 1.1	For values less than 0.1, round to the nearest 0.01 NTU. For values that exceed a limit, the SWMOR counts only those values that are above that limit based on the values you entered and after rounding—not the values displayed.

Table 7.3. How the SWMOR and SWMOR2 round the readings you enter.

30 TAC Chapter 290 Regulations Pertaining to Turbidimeters and Turbidimeter Data Integrity

In the past, there has been some confusion about the way combined filter effluent (CFE) and individual filter effluent (IFE) turbidity measurements are sampled, analyzed, recorded, and reported to the TCEQ. However, the TCEQ regulations and guidance documents are specific, and the reason for the confusion has been due to the lack of a full knowledge of the regulations and guidance.

This addendum to the student text for this directed assistance module has been assembled so that most of the regulatory guidance will be located in one place. Please be aware that the TCEQ regulations are subject to review and change, and this appendix is up to date as of July 30, 2015, but any subsequent updates will not be presented here.

The regulatory references are from 30 Texas Administrative Code (TAC) Chapter 290, entitled "Public Drinking Water." Both Subchapter D and Subchapter F are referenced here.

Chapter 290 - Public Drinking Water

§290.42 Water Treatment

§290.42(d)(11)(E) Filter Monitoring

The filters shall be provided with facilities to monitor the performance of the filter. Monitoring devices shall be designed to provide the ability to measure and record turbidity as required by §290.111 of this title.

§290.42(d)(11)(E)(i) Each filter shall be equipped with a sampling tap so that the effluent turbidity of the filter can be individually monitored.

§290.42(d)(11)(E)(ii) Each filter operated by a public water system that serves fewer than 10,000 people shall be equipped with an on-line turbidimeter and recorder which will allow the operator to *measure and record the turbidity at 15-minute intervals*. The executive director may allow combined filter effluent monitoring in lieu of individual filter effluent monitoring under the following conditions:

§290.42(d)(11)(E)(ii)(I) The public water system has only two filters that were installed prior to October 1, 2000, *and were never equipped with individual on-line turbidimeters and recorders;* and

§290.42(d)(11)(E)(ii)(II) The plant is equipped with an on-line turbidimeter and recorder which will allow the operator to measure and record the turbidity level of the combined filter effluent *at a location prior to clearwell storage* at 15-minute intervals.

§290.42(d)(11)(E)(iii) Each filter operated by a public water system that serves at least 10,000 people shall be equipped with an on-line turbidimeter and recorder which will allow the operator *to measure and record* the turbidity at 15-minute intervals.

§290.42(d)(11)(E)(iv) Each filter installed after October 1, 2000, shall be equipped with an on-line turbidimeter and recorder which will allow the operator to determine the turbidity at 15-minute intervals.

§290.42(d)(11)(E)(v) Each filter unit that is not equipped with an on-line turbidimeter and recorder shall be equipped with a device to indicate loss of head through the filter. In lieu of loss-of-head indicators, declining rate filter units may be equipped with rate-of-flow indicators.

Adopted July 1, 2015 Effective July 30, 2015

§290.46 Minimum Acceptable Operating Practices for Drinking Water Systems

§290.46(f) Operating records and reports.

Water systems must maintain a record of water works operation and maintenance activities and submit periodic operating reports.

§290.46(f)(1) The public water system's operating records must be organized, and copies must be kept on file or stored electronically.

§290.46(f)(2) The public water system's operating records must be accessible for review during inspections and be available to the executive director upon request.

§290.46(f)(3)(B) The following records shall be retained for at least three years:

§290.46(f)(3)(B)(iv) the calibration records for laboratory equipment, flow meters, rate-of-flow controllers, on-line turbidimeters, and on-line disinfectant residual analyzers;

§290.46(f)(3)(C) The following records shall be retained for a period of five years after they are no longer in effect:

§290.46(f)(3)(C)(iv) the turbidity monitoring results and exception reports for individual filters as required by §290.111 of this title.

§290.46(f)(3)(E) The following records shall be retained for at least ten years:

§290.46(f)(3)(E)(i) copies of Monthly Operating Reports and any supporting documentation including turbidity monitoring results of the combined filter effluent;

§290.46(f)(3)(G) A public water system shall maintain *records relating to special studies* and pilot projects, *special monitoring*, and other system-specific matters as directed by the executive director.

§290.46(s) Testing Equipment.

§290.46(s)(2)(B) Turbidimeters shall be properly calibrated.

§290.46(s)(2)(B)(i) Benchtop turbidimeters shall be calibrated with primary standards at least once every 90 days. *Each time the turbidimeter is calibrated with primary standards, the secondary standards shall be restandardized*.

§290.46(s)(2)(B)(ii) The calibration of benchtop turbidimeters shall be checked with secondary standards each time a series of samples is tested, and if necessary, recalibrated with primary standards.

§290.46(s)(2)(B)(iii) On-line turbidimeters shall be calibrated with primary standards at least once every 90 days.

§290.46(s)(2)(B)(iv) *The calibration of on-line turbidimeters shall be checked at least once each week* with a primary standard, a secondary standard, or the manufacturer's proprietary calibration confirmation device or by comparing the results from the on-line unit with the results from a properly calibrated benchtop unit. If necessary, the on-line unit shall be recalibrated with primary standards.

Adopted July 1, 2015 Effective July 30, 2015

§290.104. Summary of Maximum Contaminant Levels, Maximum Residual Disinfectant Levels, Treatment Techniques, and Action Levels

§290.104(g) Surface water treatment.

Systems treating surface water or groundwater under the direct influence of surface water must meet the turbidity treatment technique requirements as provided in §290.111 of this title (relating to Surface Water Treatment).

§290.104(g)(1) The turbidity level of the combined filter effluent must never exceed 1.0 nephelometric turbidity unit (NTU) and the turbidity level of the combined filter effluent must be 0.3 NTU or less in at least 95% of the samples tested each month.

Adopted December 19, 2007 Effective January 9, 2008

§290.111 Surface Water Treatment

§290.111(e)(1) Treatment technique requirements for combined filter effluent.

Treatment plants using conventional media filtration must meet the following turbidity requirements.

§290.111(e)(1)(A) The turbidity level of the combined filter effluent must never exceed 1.0 nephelometric turbidity unit (NTU).

§290.111(e)(1)(B) The turbidity level of the combined filter effluent must be 0.3 NTU or less in at least 95% of the samples tested each month.

§290.111(e)(2) Performance criteria for individual filter effluent.

The filtration techniques must ensure the public water system meets the following performance criteria.

§290.111(e)(2)(A) The turbidity from each individual filter effluent should never exceed 1.0 NTU.

§290.111(e)(2)(B) At a public water system that serves 10,000 people or more, the turbidity from each individual filter effluent should not exceed 0.5 NTU at four hours after the individual filter is returned to service after backwash or shutdown.

§290.111(e)(3) Routine turbidity monitoring requirements.

A system must monitor the performance of its filtration facilities.

§290.111(e)(3)(A) A system that serves fewer than 500 people and continuously monitors the turbidity level of each individual filter must measure and record the turbidity level of the combined filter effluent at least once each day that the plant is in operation.

§290.111(e)(3)(B) A system that serves at least 500 people and continuously monitors the turbidity level of each individual filter must measure and record the turbidity level of the combined filter effluent at least every four hours that the system serves water to the public.

§290.111(e)(3)(C) Except as provided in subparagraph (D) of this paragraph, a system must continuously monitor the filtered water turbidity at the effluent of each individual filter and record the turbidity value every 15 minutes.

§290.111(e)(3)(D) A system that serves fewer than 10,000 people and monitors combined filter effluent turbidity in lieu of individual filter effluent turbidity under the provisions of §290.42(d)(11)(E)(ii) of this title (relating to Water Treatment) must:

§290.111(e)(3)(D)(i) continuously monitor the turbidity of the combined filter effluent and record the turbidity value every 15 minutes; and

§290.111(e)(3)(D)(ii) measure and record the turbidity level at the effluent of each filter at least once each day the plant is in operation.

§290.111(e)(4) Special investigation requirements.

A system which fails to produce water with acceptable turbidity levels must investigate the cause of the problem and take appropriate corrective action. The executive director can waive these special monitoring requirements for systems that have a corrective action schedule approved by the executive director.

§290.111(e)(4)(A) A public water system that fails to meet the turbidity criteria specified in paragraph (2) of this subsection must conduct additional monitoring.

§290.111(e)(4)(A)(i) Each time a filter exceeds an applicable filtered water turbidity level specified in paragraph (2) of this subsection for two consecutive 15-minute readings, the public water system must either identify the cause of the exceedance or produce a filter profile on the filter within seven days of the exceedance.

§290.111(e)(4)(A)(ii) Each time a filter exceeds the filtered turbidity level specified in paragraph (2)(A) of this subsection for two consecutive 15-minute readings on three separate occasions during any consecutive three-month period, the public water system must conduct a filter assessment on the filter within 14 days of the third exceedance.

§290.111(e)(4)(A)(iii) Each time the filtered water turbidity level for a specific filter or any combination of individual filters exceeds 2.0 NTU on two consecutive 15-minute readings during two consecutive months, the public water system must participate in a third- party comprehensive performance evaluation (CPE). If the system serves at least 10,000 people, the CPE must be conducted within 90 days of the first exceedance in the second month. If the system serves fewer than 10,000 people, the CPE must be conducted within 120 days of the first exceedance in the second month.

§290.111(e)(4)(B) A system that serves fewer than 10,000 people, monitors combined filter effluent turbidity in lieu of individual filter effluent turbidity, and fails to meet the turbidity criteria in paragraph (1)(A) of this subsection must conduct additional monitoring. The executive director may waive these special monitoring requirements for systems that have a corrective action schedule approved by the executive director.

§290.111(e)(4)(B)(i) Each time the combined filter effluent turbidity level exceeds 1.0 NTU for two consecutive 15-minute readings, the public water system must either identify the cause of the exceedance or complete a filter profile on the combined filter effluent within seven days of the exceedance.

§290.111(e)(4)(B)(ii) Each time the combined filter effluent turbidity level exceeds 1.0 NTU for two consecutive 15-minute readings on three separate occasions during any consecutive three-month period, the public water system must conduct a filter assessment on each filter within 14 days of the third exceedance.

§290.111(e)(4)(B)(iii) Each time the combined filter effluent turbidity level exceeds 2.0 NTU on two consecutive 15-minute readings during two consecutive months, the public water system must participate in a third-party comprehensive performance evaluation within 120 days of the first exceedance in the second month.

§290.111(e)(5) Analytical requirements for turbidity.

All monitoring required by this subsection must be conducted by a facility approved by the executive director and using methods that conform to the requirements of §290.119 of this title. *Equipment used for compliance measurements must be maintained and calibrated in accordance with §290.46(s)* of this title (relating to Minimum Acceptable Operating Practices for Public Drinking Water Systems).

§290.111(e)(5)(A) Turbidity must be measured with turbidimeters that use one of the following methods:

§290.111(e)(5)(A)(i) EPA Method 180.1 and Standard Method 2130B;

§290.111(e)(5)(A)(ii) Great Lakes Instruments Method 2; or

§290.111(e)(5)(A)(iii) Hach FilterTrak Method 10133.

§290.111(e)(5)(B) A system monitoring the performance of individual filters with on-line turbidimeters and recorders may monitor combined filter effluent turbidity levels by either continuously monitoring turbidity levels with an on-line turbidimeter or measuring the turbidity level in grab samples with a bench-top turbidimeter.

§290.111(e)(5)(C) Continuous turbidity monitoring must be conducted using a continuous, on-line turbidimeter and a device that records the turbidity level reading at least once every 15 minutes.

§290.111(e)(5)(C)(i) Turbidity data may be recorded electronically by a supervisory control and data acquisition system (SCADA) or on a strip chart. The recorder must be designed so that the operator can accurately determine the turbidity level readings at 15-minute intervals.

§290.111(e)(5)(C)(ii) If there is a failure in the continuous turbidity monitoring equipment at a system serving 10,000 people or more, the system must conduct grab sampling every four hours in lieu of continuous monitoring, but for no more than five working days following the failure of the equipment.

§290.111(e)(5)(C)(iii) If there is a failure in the continuous turbidity monitoring equipment at a system serving fewer than 10,000 people malfunctions, the system must conduct grab sampling every four hours in lieu of continuous monitoring, but for no more than 14 working days following the failure of the equipment.

§290.111(e)(5)(D) A system that monitors combined filter effluent turbidity in lieu of individual filter effluent turbidity under §290.42(d)(11)(E)(ii) of this title must monitor the performance of individual filters using a bench-top turbidimeter.

§290.111(f)(3) Analytical requirements.

All monitoring required by this subsection must be conducted by a facility approved by the executive director and using methods that conform to the requirements of §290.119 of this title. Equipment used for compliance measurements must be maintained and calibrated in accordance with §290.46(s) of this title.

§290.111(f)(3)(A) Turbidity of the combined effluent must be measured with turbidimeters that meet the requirements of subsection (e)(5)(A) of this section.

§290.111(f)(3)(B) The turbidity of the water produced by each membrane unit must be measured using the Hach FilterTrak Method 10133. The executive director may approve the use of alternative technology to monitor the quality of the water produced by each membrane unit.

§290.111(f)(3)(C) A system continuously monitoring the performance of individual cartridges or membrane units may monitor combined effluent turbidity levels by either continuously monitoring turbidity levels with an on-line turbidimeter, or by measuring the turbidity level in grab samples with a bench-top turbidimeter.

§290.111(f)(3)(D) Data collected from on-line instruments may be recorded electronically by a SCADA system or on a strip chart recorder. The recorder must be designed so that the operator can accurately determine the value of readings at the monitoring interval approved by the executive director.

§290.111(f)(3)(D)(i) If there is a failure in the continuous monitoring equipment at a system serving 10,000 people or more, the system must conduct grab sampling every four hours in lieu of continuous monitoring, but for no more than five working days following the failure of the equipment.

§290.111(f)(3)(D)(ii) If there is a failure in the continuous monitoring equipment at a system serving fewer than 10,000 people, the system must conduct grab sampling every four hours in lieu of continuous monitoring, but for no more than 14 working days following the failure of the equipment.

§290.111(f)(3)(E) A system that uses cartridge filters and does not continuously monitor the turbidity of each filter unit must monitor the performance of individual filters at least once each day using a bench-top turbidimeter.

§290.111(h) Reporting requirements.

Public water systems must properly complete and submit periodic reports to demonstrate compliance with this section.

§290.111(h)(1) A system that has a turbidity level exceeding 1.0 NTU in the combined filter effluent must consult with the executive director within 24 hours.

§290.111(h)(2) A system that treats surface water sources or groundwater sources under the direct influence of surface water must submit a Surface Water Monthly Operating Report each month for each plant.

§290.111(h)(2) (A) A system that uses alternative treatment technologies or has been assigned a Bin 2, Bin 3, or Bin 4 classification under subsection (c)(3)(B) of this section must submit a Surface Water Monthly Operating Report (commission Form 0102D) for alternative technologies.

§290.111(h)(2) (B) A system that continuously monitors the performance of individual filters, but is not required to submit commission Form 0102D, must submit a Surface Water Monthly Operating Report (commission Form 0102C).

§290.111(h)(2) (C) A system that is allowed by the executive director to submit combined filter effluent turbidity in lieu of individual filter effluent turbidity under §290.42(d)(11)(E)(ii) of this title must submit a Surface Water Monthly Operational Report for Plants That Do Not Have a Turbidimeter on Each Filter (commission Form 0103) each month for each plant that treats surface water or groundwater under the direct influence of surface water.

§290.111(h)(3) A system that must complete the additional monitoring required by subsection (e)(4)(A)(i) or (B)(i) of this section must submit a Filter Profile Report for Individual Filters (commission Form 10276) with its Surface Water Monthly Operating Report.

§290.111(h)(4) A system that must complete the additional monitoring required by subsection (e)(4)(A)(ii) or (B)(ii) of this section must submit a Filter Assessment Report for Individual Filters (commission Form 10277) with its Surface Water Monthly Operating Report.

§290.111(h)(5) A system that must complete the additional monitoring required by subsection (e)(4)(A)(iii) or (B)(iii) of this section must submit a Comprehensive Performance Evaluation Request Form (commission Form 10278) with its Surface Water Monthly Operating Report.

§290.111(h)(6) A system must submit any additional reports required by the executive director to verify the level of pathogen removal or inactivation achieved by the system's treatment plants.

§290.111(i) Compliance determination.

Compliance with the requirements of this section must be determined using the criteria of this subsection.

§290.111(i)(1) A public water system that fails to complete source water monitoring or conduct the routine monitoring tests and any applicable special investigations required by this section commits a monitoring violation.

§290.111(i)(2) A public water system that fails to submit a report required by subsection (h) of this section commits a reporting violation.

§290.111(i)(3) A public water system using conventional filters that has a turbidity level exceeding 5.0 NTU in the combined filter effluent commits an acute treatment technique violation.

§290.111(i)(4) A public water system using membrane filters that has a turbidity level exceeding 1.0 NTU in the combined filter effluent commits an acute treatment technique violation.

§290.111(i)(5) Except as provided in paragraphs (3) and (4) of this subsection, a public water system that violates the requirements of subsections (c), (d)(1), (e)(1), and (f)(1) of this section commits a non-acute treatment technique violation.

§290.111(i)(6) A system that fails to request a bin classification within six months of completing a round of source water monitoring commits a treatment technique violation.

§290.111(i)(7) A system that fails to correct the performance-limiting factors identified in a comprehensive performance evaluation conducted under the requirements of subsection (e)(4)(A)(iii) or (B)(iii) of this section commits a violation.

§290.111(i)(8) A system that fails to properly issue a public notice required by subsection (j) of this section commits a violation.

Adopted July 1, 2015 Effective July 30, 2015

§290.122. Public Notification

§290.122(a) Public notification requirements for acute violations or situations.

The owner or operator of a public water system must notify persons served by their system of any maximum contaminant limit (MCL), maximum residual disinfectant level (MRDL), treatment technique violation, or other situation that poses an acute threat to public health. Each notice required by this section must meet the requirements of subsection (d) of this section.

§290.122(a)(1) Situations that pose an acute threat to public health include:

§290.122(a)(1)(B) an acute turbidity issue at a treatment plant that is treating surface water or groundwater under the direct influence of surface water, specifically:

§290.122(a)(1)(B)(i) a combined filter effluent turbidity level above 5.0 nephelometric turbidity units (NTU);

§290.122(a)(1)(B)(ii) a combined filter effluent turbidity level above 1.0 NTU at a treatment plant using membrane filters; or

§290.122(a)(1)(B)(iii) a combined filter effluent turbidity level above 1.0 NTU at a plant using other than membrane filters at the discretion of the executive director after consultation with the system; or

§290.122(a)(1)(B)(iv) failure of a system with treatment other than membrane filters to consult with the executive director within 24 hours after a combined filter effluent reading of 1.0 NTU;

§290.122(a)(2) The initial acute public notice and/or boil water notice required by this subsection shall be issued as soon as possible, but in no case later than 24 hours after the violation or situation is identified. The initial public notice for an acute violation or situation shall be issued in the following manner.

§290.122(a)(2)(A) The owner or operator of a water system with an acute microbiological or turbidity violation as described in paragraph (1)(A) or (B) of this subsection shall include a boil water notice issued in accordance with the requirements of §290.46(q) of this title (relating to Minimum Acceptable Operating Practices for Public Drinking Water Systems).

§290.122(a)(2) (B) The owner or operator of a community water system shall furnish a copy of the notice to the radio and television stations serving the area served by the public water system.

§290.122(a)(2)(C) The owner or operator of a community water system shall publish the notice in a daily newspaper of general circulation in the area served by the system. If the area is not served by a daily newspaper of general circulation, notice shall instead be issued by direct delivery or by continuous posting in conspicuous places within the area served by the system. Other methods of delivery may include electronic delivery or alert systems (e.g. reverse 911).

§290.122(a)(2)(D) The owner or operator of a noncommunity water system shall issue the notice by direct delivery or by continuously posting the notice in conspicuous places within the area served by the water system. Other methods of delivery may include electronic delivery or alert systems (e.g. reverse 911).

§290.122(a)(2)(E) If notice is provided by posting, the posting must remain in place for as long as the violation or situation exists or seven days, whichever is longer.

§290.122(a)(3) The owner or operator of a water system required to issue an initial notice for an acute MCL or treatment technique violation shall issue additional notices. The additional public notices for acute violations shall be issued in the following manner.

§290.122(a)(3)(A) Not later than 45 days after the violation, the owner or operator of a community water system shall notify persons served by the system using mail (by direct mail or with the water bill) or hand delivery. The executive director may waive mail or hand delivery if it is determined that the violation was corrected within the 45-day period. The executive director must make the waiver in writing and within the 45-day period.

§290.122(a)(3)(B) The owner or operator of a community water system must issue a notice at least once every three months by mail delivery (by direct mail or with the water bill) or by hand delivery, for as long as the violation exists.

§290.122(a)(3)(C) If the owner or operator of a noncommunity water system issued the initial notice by continuous posting, posting must continue for as long as the violation exists and in no case less than seven days. If the owner or operator of a noncommunity water system issued the initial notice by direct delivery, notice by direct delivery must be repeated at least every three months for as long as the violation exists.

§290.122(a)(4) The owner or operator of the public water system must issue a notice when the public water system has corrected the acute violation or situation. This notice must be issued in the same manner as the original notice was issued.

§290.122(a)(5) Copies of all notifications required under this subsection must be submitted to the executive director within ten days of its distribution.